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REAUTHORIZATION OF THE EARTHQUAKE HAZARDS REDUCTION ACT

HEARING

BEFORE THE

SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE

OF THE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION

UNITED STATES SENATE

ONE HUNDREDTH CONGRESS

FIRST SESSION

ON

REAUTHORIZATION OF THE EARTHQUAKE HAZARDS REDUCTION ACT

APRIL 23, 1987

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REAUTHORIZATION OF THE EARTHQUAKE HAZARDS REDUCTION ACT

THURSDAY, APRIL 23, 1987

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE,
Washington, DC.

The subcommittee met, pursuant to notice, at 9:45 a.m. in room SR-253 Russell Senate Office Building, Hon. Albert Gore, Jr. presiding.

Staff members assigned to this hearing: Pat Windham, professional staff member and Mark Farrell, minority professional staff member.

OPENING STATEMENT BY SENATOR GORE

Senator GORE. This hearing will come to order.

And I would like to begin by apologizing to our witnesses and guests for the lateness of our start. The delay was unavoidable.

Large earthquakes are one of the most serious natural hazards facing the United States. The risk in the Western part of the United States is, of course, well known.

Less well known is the fact that devastating earthquakes have also struck the central part of our country, and the eastern part of our country. Three great tremors struck the New Madrid area of the Mississippi Valley in 1811 and 1812. Those earthquakes affected a huge area, ringing church bells as far away as Boston, and changing the course of the Mississippi River.

In 1886, an earthquake levelled the city of Charleston, South Carolina. In total, 37 states, and 70 million Americans, are exposed to at least moderate earthquake hazards.

The cost of a major earthquake in lives and loss of property is almost beyond belief. A recent government report estimates that a large—in the range of 8.6—daytime quake in Memphis, Tennessee would kill 3,800 people and cause almost $32 billion in property damage. That's just in that one city alone.

In the smaller city of Paducah, Kentucky, the numbers would be over 200 dead and almost $6 billion in property losses.

In the disastrous September 19, 1985, earthquake in Mexico City, 8,000 lives were lost as a result of the total or partial collapse of 500 buildings, including schools, hospitals and apartment houses.

Mexico City had a modern building code. Some aspects of the tremor were simply more severe than the planners had anticipated.

Ten years ago, Congress passed the Earthquake Hazard Reduction Act of 1977. Its purpose is as important today as it was then, and I quote, "to reduce the risks of life and property from future earthquakes in the United States through the establishment and maintenance of an effective earthquake hazards reduction program."

At this morning's reauthorization hearing, we will review the progress that has been made under the Act, and the earthquake hazards reduction program, and we will determine whether or not any changes need to be made.

We will hear from representatives of the principal federal agencies, as well as from three knowledgeable outside experts. We will ask several questions throughout this hearing.

Over the past ten years, for example, how well has the earthquake program met its goals of improved prediction and improved preparedness?

How prepared are major American cities, including cities in the central and eastern states?

And have we set the right priorities in current efforts to mitigate earthquake hazards?

We also face difficult funding questions, of course. This year the Administration proposes to cut some $2 million from the Geological Survey's earthquake program. I want to know what effect those cuts would have on our ability to identify and cope with seismic hazards.

Finally, I want to raise a relatively new issue, the question of earthquake insurance. There is no specific legislative proposal before this committee currently, but both industry leaders and state officials have expressed concern about the ability of the U.S. insurance system, and indeed the financial system, to handle the large losses that a major earthquake could cause.

Senators Hollings and Danforth have opening statements for the record which I will include at this point.

[The statement follows:]

OPENING STATEMENT BY THE CHAIRMAN

The disastrous September 1985 earthquake in Mexico City starkly demonstrated both the hazards that earthquakes pose and the need to improve preparedness. We still need the National Earthquake Hazards Reduction Program, and for that reason I strongly support its reauthorization.

I hope that today's hearing will help the Committee better understand where progress has been made and where further work is needed. We clearly must improve preparedness in the central and eastern states. We need continued research to improve our ability to predict earthquakes. And we must improve coordination within the four-agency federal program.

Today's distinguished witnesses will help us examine these issues, and I look forward to reviewing their testimony.

OPENING STATEMENT BY SENATOR DANFORTH

Preparing for and protecting against earthquakes is a public policy issue of considerable importance. In 1811 and 1812, possibly the most powerful earthquakes known to the continental United States occurred in New Madrid, Missouri. Scientists believe the earthquakes registered 8.6, 8.4, and 8.7 on the Richter scale, changed the course of the Mississippi River, and woke up President Madison who was sleeping in the White House. In the early 1800's the Midwest was sparsely populated. Today, if a similar earthquake were to occur, thousands would suffer, and

the immediate financial loss could be anywhere from $20 billion to $80 billion. The obvious long term losses would be even more significant.

Scientists warn us that a major earthquake in the central or eastern United States is likely by the year 2010. Our public officials need to prepare for such a catasprophe and encourage the increased use of earthquake building codes and technology. We will also need to examine how people can be financially protected against such disasters. In 1985, Senator Gorton and I asked the Congressional Research Service to study the availabilty of earthquake insurance and the financial vulnerability of insurance companies in the event of a devastating earthquake. Several weeks ago, this Committee released the report. It will provide a good starting point as we consider the issues surrounding earthquake insurance and the federal earthquake program.

Senator GORE. A major new Congressional Research Service study, prepared for this committee, and released today, illuminates the basic issues involved. Our witnesses today will shed light on this subject.

We will start this morning's testimony by hearing from representatives of the four principal agencies of the earthquake hazards reduction program.

I would like to welcome the members of our first panel, Mr. David McLoughlin, Deputy Associate Director for State and Local Programs with the Federal Emergency Management Agency; Mr. Doyle Frederick, Associate Director of the U.S. Geological Survey, and he is accompanied by Dr. John Filson, who is chief of the Office of Earthquakes, Volcanoes and Engineering with USGS; Dr. Nam Suh—have I pronounced that right?

Mr. SUH. Yes, that is correct.

Senator GORE. Dr. Nam Suh, assistant director for engineering at the National Science Foundation, who is accompanied by Dr. James Hays, director of the Earth Sciences Division at NSF; and Dr. John Lyons, Director of the National Engineering Laboratory at the National Bureau of Standards, and he is accompanied by Dr. Richard N. Wright, director of the Center for Building Technology at NBS.

We will go in the order in which I read the witnesses names. And that means, Mr. McLoughlin, that we will start with you. I welcome you. Your prepared remarks will be included in full if you care to present an oral summary, we would appreciate it.

Please proceed.

STATEMENT OF DAVID McLOUGHLIN, DEPUTY ASSOCIATE DIRECTOR, STATE AND LOCAL PROGRAMS AND SUPPORT, FEDERAL EMERGENCY MANAGEMENT AGENCY, ACCOMPANIED BY FRANK REILLY, DEPUTY ASSOCIATE ADMINISTRATOR, FEDERAL INSURANCE ADMINISTRATION

Mr. MCLOUGHLIN. Thank you, Mr. Chairman, I am pleased to appear before this subcommittee to support the reauthorization of the Earthquake Hazards Reduction Act.

The Federal Emergency Management Agency is a designated lead agency, has forwarded a request for your consideration for a two-year reauthorization of the National Earthquake Hazards Reduction program.

The request includes an authorization funding for the four principal agencies, FEMA, USGS, the National Bureau of Standards, and the National Science Foundation.

The total sum requested in 1988 is $67,078,000. $71,626,000 for fiscal year 1989. This request is comparable to the sums authorized in fiscal year 1987. As you will hear from the testimony of my colleagues and myself, significant progress has been made in reducing the potential risk to people and property posed by earthquakes.

However, much still remains to be done, and reauthorization of the program is essential for continuation of this critical work.

Mr. Chairman, my written statement, as you said, has been entered into the record. And therefore, I will keep my remarks short and focused on the principal parts of our program.

FEMA's earthquake program has six elements: program leadership; seismic design and construction standards; state and local hazards reduction; federal response planning; multi-hazard planning; and earthquake education and information transfer.

I will highlight the most important accomplishments and ongoing initiatives and the fiscal year 1988 activities in each area. But I will focus on the first three areas, where the majority of FEMA's financial and staff resources are expended.

Also with me today is Frank Reilly, who is the Deputy Associate Administrator for the Federal Insurance Administration, who will be available to answer questions that you may have, as you indicated earlier, on earthquake insurance.

The focus of FEMA's leadership responsibility is threefold: interagency coordination; reporting; and program planning.

Coordination of the earthquake program is accomplished through a comprehensive system of committees which are effectively addressing overall policy and planning, and well as coordination of specific Federal earthquake activities.

With respect to reporting, FEMA, through submittal of the annual report, provides a report to the Congress each fiscal year to report the activities that are undertaken by the four principal agencies and the other Federal agencies doing earthquake related work.

The fiscal year 1986 report was forwarded to all Members of Congress—excuse me, of this committee, in February.

The third area of FEMA's focus as lead agency is program planning. This area will receive heightened attention in fiscal year 1988 and 1989. FEMA believes that its lead agency responsibility to raise and address pertinent issues relative to the progress and future direction of the earthquake program, and to make recommendations for changes as necessary.

To accomplish this, we have initiated two actions: revision of the current five-year plan; and a survey of the first ten years of the earthquake program.

As called for by legislation, a revised five-year plan must be submitted to the Congress, to your committee, by September, 1988. To initiate the plan revision, FEMA in conjunction with the other principal agencies, has established an expert review committee.

This committee is composed of 15 nonfederal members nominated by each of the four agencies. They represent the broad spectrum of public and private groups which comprise the earthquake community.

Congress has consistently encouraged us to seek this outside expertise, and we feel that this committee is the appropriate mechanism for dealing with the needed external experience.

Recognizing it has been ten years since the passage of the Earthquake Act, we have initiated a contract to survey the first ten years of the program. The intent of this survey is to provide baseline data on the program and how it has functioned.

This is the first such review undertaken by FEMA, and it should be a benefit not only to all agencies, but to the Congress.

FEMA's second area of program activity is seismic design and construction. As was so graphically illustrated in Mexico City, the partial failure or collapse of buildings poses the greatest potential threat to life and property from an earthquake.

The importance of improved seismic design and construction standards to reducing the earthquake hazard cannot be underestimated. FEMA focuses its activities in three areas: new buildings, existing buildings, and lifelines. And with two particular communities: Federal, and nonfederal.

Within the Federal sector, a significant accomplishment was finished in 1987. Under the auspices of the interagency committee on seismic safety and construction, chaired by the National Bureau of Standards, supported by FEMA dollars, a proposed executive order on seismic resistant design and construction for Federal buildings has been developed.

State and local governments have the primary responsibility for the protection of life and property in the event of an earthquake. It is the area of nonfederal seismic design and construction where FEMA plays a unique role among the principal agencies.

In the seismic design and construction area, FEMA is the principal agency working to translate research into tools for implementation.

Further, FEMA is the primary agency, working with state and local governments, to assist them in using these tools to implement and adopt seismic design standards and provisions.

In new buildings, the building seismic safety council, with FEMA support, is engaged in a nationwide campaign to disseminate and provide technical assistance in the application of recommended provisions for the development of seismic regulations for new buildings.

These provisions, published in 1985, provide the technical basis for development and implementation of seismic resistant codes by state and local officials.

In addition, the BSSC is updating these provisions to incorporate new data and the results of emerging Mexico City research.

Existing buildings represent the greatest potential for loss of life in an earthquake. Mitigating the threat from existing buildings is one of the biggest challenges faced by state and local jurisdictions in the private sector.

We have undertaken an active program to fund the development of how-to books for state and local officials in the private sector to address their existing hazardous building problem, to set priorities, and to develop long term mitigation programs based on the current state of the art.

In the area of lifelines, the potential for loss of property and economic destruction nationwide from a major earthquake is staggering.

We have under development a plan for addressing the seismic safety of lifeline facilities nationwide.

As I noted earlier, state and local governments have the primary responsibility for the protection of life and property, while the greatest potential for reduction of risk lies in seismic design, there are other activites that must be undertaken by states and localities to identify the risk and to protect the life and property of their constituents.

FEMA is the primary agency in the earthquake program providing grants to state and local governments, and we do this generally in 12 high risk areas that encompass 19 states and territories.

Within these 12 high risk areas, we support a broad spectrum of activities that include vulnerability assessment, response planning, mitigation planning, and public awareness and education.

The scope of these activities will vary in each state or locality with the level of seismic risk, the level of earthquake awareness, and the availability of mitigation tools.

Today I would like to give the committee a quick cross-section of these activities.

California clearly represents the most aware and advanced state in earthquake hazard reduction. The Southern California project has become a model for other state and local efforts.

The planning process and materials developed by SCEPP, and its sister organization to the north, the Bay Area project, has been widely disseminated, and can be used as a starting point for other state and local projects.

In Washington State, FEMA financially supported the Washington State seismic safety council in their development and forwarding to the governor of a long range plan for reducing the earthquake risk in Washington.

In the central U.S., under the leadership of the central U.S. earthquake consortium, which is funded by FEMA, seven states have joined to promote implementation of region-wide solutions for earthquake hazard reduction.

In the eastern U.S. there is an increasing awareness by state and local officials that a serious earthquake could occur in the east. The State of Massachusetts was instrumental in organizing the New England seismic advisory council, and is in the process of developing an earthquake loss estimation study, one of the basic tools necessary to begin preparedness planning, and for all other earthquake reduction efforts.

A major change will be made in FEMA's approach to state and local programs in fiscal year 1988. We will require the states to cost share on a 50-50 basis the funding of their earthquake activities.

Cost sharing of earthquake activities will help promote a state commitment, as well as institutionalize these activities within state and local government structure.

A good example of this is California. The state has cost shared their earthquake hazards reduction activity with FEMA since 1980.

In Federal response planning, the plan for Federal response to a catastrophic earthquake, has been completed, and is currently being signed by the 25 agencies with specific responsibilities designated in the new plan.

Although the Chilean and Mexico City earthquakes heightened public awareness and stimulated media interest in earthquakes, the level of public awareness and knowledge about the effects is still debatable.

We are playing a primary role in initiating activities to educate and prepare the public on the effects of earthquakes, and how they can work to reduce and minimize the effects of the earthquakes.

Of note this year is the guidebook for developing a school earthquake safety program, work with the Children's Television Workshop, an active program of development and deployment of earthquake-related training courses; and a series of seminars which will look at how research results do or don't get applied.

Having provided an overview of what FEMA is doing to accomplish the goals of the earthquake program, I would like to take a moment in conclusion to address an issue that we believes merits consideration for the program's future effectiveness.

We believe there is a need for the continuation of strong earthquake research programs, to provide new and improved scientific techniques and date as a sound technical basis for all earthquake hazard reduction activities.

However we do believe that a larger portion of this research should be specifically targeted for applied research. Specifically, this research should be targeted to solve a specific problem, such as an existing building retrofit, and the research should result in a useable product such as a retrofit handbook.

Currently only a small portion of the earthquake budget is devoted to this type of research. We believe that applied research is critical for addressing the most pressing life-safety problems associated with earthquake hazards reduction.

FEMA has a unique role in accomplishing the goals and objectives of the national program, not only as lead agency, but more critically, as the primary work agency working with state and local governments.

We firmly believe that the success of the earthquake program will depend on how well we at the Federal level have assisted state and local governments and the private sector in effecting their earthquake hazard reduction measures.

Mr. Chairman, thank you for the opportunity for appearing this morning.

[The statement follows:]

STATEMENT OF DAVE McLOUGHLIN, DEPUTY ASSOCIATE DIRECTOR, STATE AND LOCAL PROGRAMS AND SUPPORT, FEMA

I am pleased to appear before this session of the Committee on Commerce, Science and Transportation, Subcommittee on Science, Technology and Space to support the reauthorization of the Earthquake Hazards Reduction Act of 1977, as amended. The Federal Emergency Management Agency (FEMA), as designated lead agency, has forwarded for your consideration a request for two year reauthorization of the National Earthquake Hazards Reduction Program (NEHRP). This request includes authorization of funding for the four principal agencies of the NEHRP: FEMA, United States Geological Survey (USGS), National Science Foundation (NSF) and National Bureau of Standards (NBS) for Fiscal Years 1988 and 1989. The total sum requested in FY 88 is $67,078,000 and $71,626,000 in FY 89. This request is comparable to the sums authorized in Fiscal Year 1987. As you will hear from the testimony of my colleagues and myself, significant progress has been made in reducing the potential risk to people and property posed by earthquakes. However, much still remains to be done and reauthorization of the Program is essential for the continuation of this critical work.

My remarks today will include a statement on the objectives of the NEHRP and a brief review of the legislative history of the NEHRP. This will help put into perspective my discussion of FEMA's activities undertaken to fulfill our charge under the Earthquake Hazards Reduction Act.

The Earthquake Hazards Reduction Act of 1977 (P.L. 95-124), as amended, has as its purpose the reduction of the risks to life and property in the United States from future earthquakes through the establishment and maintenance of an effective earthquake hazards reduction program. The objectives of the NEHRP include earthquake hazard identification and vulnerability analysis, seismic design and construction standards, earthquake prediction, preparedness and response planning, public education, fundamental and applied research studies and mitigation.

In creating the NEHRP, Congress brought together the earthquake hazard research programs already underway of the USGS and NSF. The original Act called for the designation of a lead agency to provide overall Program coordination, direction and management. As this legislation was being developed, it was determined that the lead agency role could be best fulfilled by an implementing agency. It was further recognized that the results of the earthquake related research must be applied and implemented so that the goal of reducing earthquake hazards on a national level could be achieved. Following the creation of FEMA in 1979, the Act was amended in 1980 to designate FEMA as the lead agency with the primary responsibility to plan and coordinate the NEHRP. In addition, FEMA was charged with undertaking activities that, when carried out, would effect earthquake hazards reduction. This legislative assignment to FEMA was made

because FEMA's overall mission is to coordinate Federal emergency management activities (preparedness, response, recovery, and mitigation) for all types of disasters - natural and manmade - and to provide technical and financial assistance to State and local governments in carrying out their emergency management programs. Also, FEMA, through its civil defense and other existing preparedness programs, already had developed the emergency management infrastructure which could be used to complement and support implementation of earthquake hazards reduction efforts.

With the addition of FEMA as a principal agency, the NEHRP changed from a research program to an integrated and comprehensive Federal program for earthquake hazards reduction. It was a recognition by Congress that once the technical or research base was developed, State and local governments must play a primary role in earthquake hazards reduction since they ultimately bear the responsibility for the protection of life and property. It is for this reason that FEMA maintains a unique role among the principal agencies as being the primary agency responsible for translating the research programs of the other agencies into effective earthquake hazard reduction measures at the State and local level.

With this as background, FEMA developed a multi-faceted approach to its responsibilities under the NEHRP.

The FEMA Earthquake Program has 6 program elements:

(1) Program Leadership
(2) Seismic Design and Construction Standards
(3) State and Local Hazards Reduction
(4) Federal Response Planning
(5) Multi-hazard Planning
(6) Earthquake Education and Information Transfer

This testimony will highlight accomplishments, ongoing activities and Fiscal Year 88 activities in each area but will focus on the first three areas where the majority of FEMA's financial and staff resources are expended.

Program Leadership

As noted earlier, in creating the NEHRP Congress intended to provide a coherent program that would work in a rationale way to reduce the potential damage from earthquakes. The diversity of agencies, issues and groups involved in earthquake hazards reduction required that a lead agency be designated to coordinate these diverse efforts, recommend complementary efforts and to assure dissemination and implementation of scientific knowledge in the appropriate public and private sectors.

The focus or goal of FEMA's leadership responsibilities is threefold:

(1) Provide for effective coordination of the NEHRP;
(2) Provide for comprehensive reporting to Congress on the status of the NEHRP; and
(3) Provide for review, analysis, assessment and revision of the NEHRP as necessary.

Coordination of the NEHRP is accomplished through a comprehensive system of committees. These are the Policy Coordinating Group (PCG), the Interagency Coordination Committee (ICC), the Federal Response Planning Subcommittee of the ICC, and the Interagency Coordination Committee on Seismic Safety in Construction (ICSSC), also a subcommittee of the ICC. The ICC is composed of program-manager level representatives of the four principal agencies as well as other departmental agencies involved in earthquake work. Regular meetings of the ICC provide for discussion of program issues and activities and insures overall program coordnation. When issues can not be resolved at the ICC, they are forwarded to the PCG which is composed of senior-policy level officials of the four principal agencies. This Group provides guidance on program policy, budget and planning issues. The ICSSC is chaired by NBS but FEMA provides the funding for the Secretariate of this Committee. The purpose of the ICSSC is to develop and promote a strong seismic design and construction mitigation program throughout the Federal community. The importance of a strong Federal program was evidenced in the failure of government buildings in the 1985 Mexico City earthquake.

Although continued improvement has been recognized in all committees, there has been two accomplishments of note. The Federal Response Planning subcommittee approved and forwarded to the 25 member agencies for signature, the Plan for Federal Response to a Catastrophic Earthquake. Secondly, the ICSSC developed a proposed Executive Order on Seismic Safety for Federal Buildings.

The second lead agency focus is submittal to Congress of the Annual Report on the NEHRP as required under Section 6 of the legislation.

FEMA's submittal of the Annual Report provides to Congress a comprehensive report of each Fiscal Year activities undertaken by the four principal agencies and the other Federal agencies doing earthquake related work. This report is a considerable undertaking and requires the cooperation of all agencies involved. The FY 86 report was sent to Congress in February and it is commended to your attention. Over the past three years, FEMA has become justifiably proud of the content and timely delivery of this document.

The final area of focus as lead agency is the review, assessment and revision of the NEHRP. This particular area is receiving heightened attention right now. FEMA believes it is a lead agency responsibility to raise and address pertinent issues relative to all aspects of the NEHRP. We also believe it is important to review the progress of the Program, to look toward future directions and to make or recommend changes as necessary. To accomplish these activities, FEMA has initiated two actions, revision of the current NEHRP 5-Year Plan and a survey of the first ten years of the NEHRP.

As called for by the legislation, a revised NEHRP 5-Year Plan must be submitted to Congress by September 1988. To initiate the Plan revision process, FEMA, in conjunction with the other principal agencies, has established an Expert Review Committee. This Committee is composed of 15 non-Federal members nominated by each of the four agencies.

Each member was nominated because of his or her particular technical expertise. They also represent the broad spectrum of public and private groups which comprise the earthquake community.

Congress has consistently encouraged FEMA to seek outside expertise on the NEHRP and we feel this Committee is the appropriate mechanism for soliciting this expertise.

The Committee has been given four tasks to perform:

(1) to review the program structure of the current 5-Year Plan and recommend changes if necessary;

(2) to review the NEHRP program and identify program specific issues to be considered by the agencies over the next 5 years;

(3) to review the NEHRP and identify issues which impact the program as a whole which should be considered over the next 5 years; and

(4) to recommend options for resolving these issues.

The report of the Committee will be forwarded to the principal agencies for their consideration in revising the 5-Year Plan.

Concurrent with this process, FEMA, recognizing that it has been ten years since the passage of the Earthquake Hazards Reduction Act, has initiated a contract to survey the first ten years of the NEHRP. The intent of this survey is to provide baseline data on the Program and how it has functioned. This is the first such review undertaken by FEMA and it should be of benefit to all of the agencies as they begin to revise the 5-Year Plan.

Seismic Design and Construction Standards

As was so graphically illustrated in Mexico City, the partial failure or the collapse of buildings poses the greatest potential threat to life and property from an earthquake. The importance of improved seismic design and construction standards to reducing the earthquake hazard can not be underestimated. Because of this significant payoff in hazard reduction, FEMA allocates approximately $1.5 million of its earthquake appropriations to this area. The focus of FEMA's work is in three areas; new buildings, existing buildings and lifelines for two distinct constituencies, the Federal and Non-Federal communities. The Federal efforts will be briefly discussed and emphasis will be placed on the non-Federal sector.

Under the auspices of the ICSSC, a proposed Executive Order on seismic resistant design for Federal buildings was developed. The ICSSC has also developed Federal Guidelines for seismic resistant design for new buildings. Currently, in the area of existing Federal buildings, the ICSSC is in the process of reviewing proposed Federal Guidelines for seismic resistant design for existing buildings. Under lifelines, a Plan is currently being developed which will address both Federal and non-Federal sectors. Under this Plan, actions specifically applicable to the safety of Federal buildings will be recommended and implementation activities identified.

State and local governments have the primary responsibility for the protection of life and property in the event of an earthquake. It is in the area of non-Federal seismic design and construction where FEMA plays a unique role among the principal agencies. In the seismic design and construction area, FEMA is the primary agency working to translate research into tools for implementation. Further, FEMA is the primary agency working with State and local officials to assist them in using these tools to implement and adopt seismic design standards and provisions. The focus of FEMA's program for accomplishing this is through the development of practical "how to" handbooks and guidelines and the provision of technical assistance to State and local officials, buildings and code officials and private design and construction professionals for new buildings, existing buildings and lifelines.

In 1985, FEMA published the NEHRP Recommended Provisions the Development of Seismic Regulations for New Buildings for use by State, local and private sector groups. This was the first such national document developed through a consensus process. This process, employed by the Building Seismic Safety Commission, included over 57 research, construction, design, and code organizations. These provisions have been recognized in several national engineering forums as a significant accomplishment and as the potential basis for a single uniform national model seismic building standard. FEMA's current efforts are focused on a campaign of widespread dissemination and technical assistance in the application of these Provisions. The dissemination efforts are particularly targeted to nationwide developers and owners, elementary and secondary school officials, health care and hotel-motel developers. FEMA is also in the process of updating the Provisions to incorporate new data and the results of the research on building performance from Mexico City. The update is expected to be completed in FY 88.

Existing buildings represent the greatest potential loss of life in an earthquake. Mitigating the threat from existing buildings is one of the biggest challenges faced by States, locals and the private sector.

The basis for addressing this challenge is a Plan developed for FEMA by the Applied Technology Council, Building Seismic Safety Council and Earthquake Engineering Research Institute. The Plan development process involved a large number of organizations and specialists in earthquake engineering, public policy and other disciplines concerned with earthquake hazardous buildings. The Plan included research, modeling, development of engineering techniques and development of practical use manuals. The Plan identified and made recommendations for activities to be undertaken by the NEHRP agencies. Currently, FEMA has made a major commitment to implementing the recommendations called for in the Plan. Also, NSF, through its unsolicited proposal process, is funding research related to the existing building problem.

FEMA has undertaken an active program to fund the development of "how to" handbooks for States, locals and the private sector to assess their existing hazardous building problem, set priorities and develop long-term mitigation programs based on the current state of the art.

The following handbooks, initiated in FY 86 and FY 87 and to be completed in FY 88 and FY 89, will provide technical guidance to building code officials, State and local engineers, policy makers and design professionals on:

(1) how to assess the existing building hazard in a community

(2) how to evaluate the degree of seismic hazard for major types of buildings

(3) how to set priorities for rehabilitation among hazardous buildings

(4) how to estimate costs for rehabilitation of major types of buildings

(5) providing data on the typical costs of specific rehabilitation techniques

When completed and disseminated, these handbooks begin to provide the tools necessary for a community or State to implement earthquake hazards reduction programs in existing buildings and to reduce their potential losses from existing buildings should an earthquake occur.

The last element of FEMA's seismic design program is lifelines. FEMA has just initiated activities in this area. The potential scope of the lifeline problem, especially relative to potential property and economic loss should a major earthquake occur, is staggering. To begin to address this complex, diverse and critical area, FEMA adopted an approach similar to that for existing buildings. Currently under development is a Plan that will provide a roadmap for addressing the seismic safety of lifelines for both the Federal and Non-Federal sectors in the following categories: communication, electric power, water and sewer, transportation and gas and oil.

This Plan will be submitted to FEMA shortly. We already know that significant research still needs to be done to provide a sound technical base for lifeline mitigation techniques. We believe that to be effective, this research must be focused toward eventual application in order to facilitate translation of this research into implementation tools. FEMA hopes to work with NSF, possibly through the new Center in Buffalo, to support the targeted research needs to be identified in the Plan.

State and Local Hazards Reduction

As noted earlier, States and local governments have the primary responsibility for the protection of life and property. While the greatest potential for reduction of risk lies in seismic design, there are other activities that must be undertaken by State and local jurisdictions to identify the risk and to protect the life and property of their constituents. These activities comprise FEMA's State and local hazards reduction program element. FEMA allocates to this element approximately $1.5 million of its appropriated earthquake funds.

Because of the overall mission of FEMA as an agency charged to work with State and locals to prepare for, respond to and mitigate natural and manmade hazards, the earthquake program benefits from the existing emergency management structure supported by other FEMA programs.

The preparedness, response and recovery infrastructure supported by FEMA's Civil Defense Program complements and enhances FEMA's earthquake preparedness efforts at the State and local level. The recent Presidential National Security Decision Directive on Civil Defense reinforces the supportive links between natural and manmade hazards, particularly as it relates to the impact of natural hazards on national security.

Of the principal agencies, FEMA is the primary agency working with State and local officials to implement earthquake hazard reduction programs. Most often the base for these activities is found in the research programs of the USGS. FEMA is working with the USGS to more closely coordinate their program of regional hazards assessment with FEMA's State and local hazards reduction activities. FEMA currently supports programs in all 12 identified high risk areas which encompasses 19 States and territories. FEMA provides financial support for State and local programs which focus on:

hazard identification/vulnerability assessment
preparedness planning
response planning
mitigation planning
public awareness and education

Within the 12 risk areas, a broad spectrum of activities are being undertaken. The scope of these activities undertaken by the State and locals varies with the level of seismic risk data, level of earthquake awareness and availability of mitigation tools available for the project area.

A cross-section of examples of the State and local earthquake hazards reduction activities FEMA is supporting follows.

California clearly represents the most aware and advanced State in earthquake hazards reduction activities. The Southern California Earthquake Preparedness Project (SCEPP) has become a model for other State and local efforts. The planning process and materials developed by SCEPP and its sister organization to the North, the Bay Area Earthquake Preparedness Project (BAREPP), have been widely disseminated and can be used as a starting point for other State and local projects. Part of the acknowledged success of these projects can be attributed to a heightened awareness on the part of State and local officials that a very real earthquake threat exists.

This awareness found its base in scientific research and actual earthquake occurrence. However, even within California, earthquake consciousness can sometimes lag. The joint earthquake planning project between Mexico and the US/San Diego has been revitalized as a result of the Mexico City earthquake and the recent research results on seismicity in the San Diego area. This project is the only such joint planning effort between Mexico and the U.S.

Recognition that a subduction earthquake similar to Mexico City could occur in Washingon State led to the creation of the Washington State Seismic Safety Council. With FEMA's financial support this Council has forwarded to the governor for action, a long range plan for reducing the earthquake risk in the State of Washington.

As we move east of California, State and local programs reflect an ever growing awareness of the potential impact of a major earthquake. In the Central U.S., under the leadership of the Central U.S. Earthquake Consortium (CUSEC), seven States have joined to develop earthquake hazards reduction programs. A repeat of the 1811-1812 New Madrid earthquake would severely test the capability of any single State to respond, thus making inter-State mutual aid essential. CUSEC, which is funded by FEMA, is designed to promote implementation of regional solutions for earthquake hazards reduction.

The State of Kentucky, a member of CUSEC, with the support of the Governor has launched a very aggressive program of earthquake hazard reduction activities. Through the workings of their State Seismic Council, they developed a medical response plan which has since been adopted by all seven CUSEC States.

State and local activities in the east also reflect a recognition that an earthquake could happen there. The State of Massachusetts is in the process of developing and earthquake loss estimation study, one of the basic tools necessary to begin preparedness planning and all other earthquake hazards reduction efforts. Also, Massachusetts has been instrumental in organizing the New England Seismic Advisory Council.

This increasing State and local activity led FEMA to request that the National Academy of Sciences provide FEMA with recommendations on the best methodology for estimating earthquake vulnerability nationwide. Basically, FEMA asked, could a standard methodology for earthquake loss estimation be applied across the nation. The preliminary report of this Panel is due in June.

A major change will be made in FEMA's approach to State and local programs in FY 88. In FY 88, FEMA will require the States to cost share on a 50/50 basis funding of their earthquake activities. Earlier this year, FEMA had begun to explored the possibility of moving to a cost share program and had alerted the States to this possibility. FEMA concluded that State and local governments should pay the costs of these activities which they conduct and control. This is the same cost share that FEMA requires in its civil defense programs. Cost sharing of earthquake hazards reduction activities will help promote a State commitment as well as institutionalize these activities within the State and local governmental structure. A good example of this is California. The State of California has successfully cost-shared their earthquake hazard reduction activities with FEMA since 1980.

While we now have earthquake activities underway in all high risk areas, there are stumbling blocks which must be overcome. Public perception of earthquakes and the recognition of the need for personal preparedness must be improved. Among State and local officials, earthquake hazard reduction must compete with other priorities for scarce resources. More tools for implementing cost-effective earthquake hazard mitigation programs still need to be developed.

FEMA's remaining 3 earthquake program elements, Federal Response Planning, Multi-hazard Planning and Earthquake Education and Information Transfer, and staff for FEMA's earthquake program account for the remaining appropriated earthquake funds.

Federal Response Planning

Section 5 of the Earthquake Hazards Reduction Act, as amended, requires that the Director develop a plan for the Federal government's response to a catastrophic earthquake. It was acknowledged that such a plan would be necessary because any catastrophic earthquake would overwhelm the capabilities and resources of State and local governments. Under the aegis of the Subcommittee on Federal Response Planning of the ICC, FEMA and 24 other Federal agencies developed the Plan for Federal Response to a Catastrophic Earthquake. This Plan represents a milestone of significantly increased Federal Government preparedness to respond to a major earthquake in any identified high risk, high population seismic area.

The Plan establishes the policies, concept of operations and specific responsibilities upon which a Federal response would be carried out. Regional interagency planning is being initiated in FY 87 for all high risk areas to develop Federal/State coordination mechanisms, procedures, and administrative and logistical requirements that will make the Federal response possible.

The Federal Government will be participating in a State of California sponsored three-day exercise named RESPONSE 87, which will be based on a simulated catastrophic earthquake on the southern San Andreas Fault in October 1987.

Multi-Hazard Planning

Throughout the United States, there is an increasing awareness that serious earthquake could occur in the U.S. and that collateral hazards to earthquakes such as landslides, will magnify the impact of the earthquakes. FEMA has a project underway with the State of Colorado to develop a model State program for landslide hazard reduction. The model program and a how to handbook will be distributed to the States in FY 88. This handbook will be useful to States not typically considered earthquake high risk but having a significant landslide problem such as West Virginia.

Earthquake Education and Information Transfer

Although the Chile and Mexico City earthquakes heightened public awareness and stimulated media interest in earthquakes, the level of public awareness and knowledge about the causes and effects of earthquakes is still in question. FEMA's last program element, earthquake education and information transfer is designed to address this problem. The focus of FEMA's program is the development of educational materials and courses for the general public and specific group audiences.

FEMA is playing a primary role in initiating activities to educate and prepare the public on the effects of earthquakes and how they can work to reduce or minimize those effects.

Of significance, this year FEMA published a Guidebook for Developing a School Earthquake Safety Program. The response to this publication has been overwhelming. At the request of the State of California, FEMA has provided copies for distribution to each public and private school within the State. To date, over 25,000 copies have been distributed to States, localities and foreign governments.

Under the Natural Hazards Project funded by FEMA, the Children's Television Workshop, the Seasame Street people, have begun to prepare "Big Bird Get Ready" kits for earthquakes. These materials will address children in 3 age groups: pre-school, 6-8 and 9-11, with special messages and materials designed for each. FEMA expects these materials will be ready for testing in late FY 88. FEMA then plans a program of dissemination and training in the use of the materials for public and private groups.

FEMA also has an active program of development and deployment of earthquake related training courses for specific audiences. These courses are offered at FEMA's National Emergency Training Center (NETC) in Emmitsburg, Maryland, as well as in the field. Currently available are: Earthquake Mitigation for Utility Lifelines, designed for city and county public works directors and engineers; Non-Structural Mitigation for Hospitals; Earthquake and Fire Hazards Mitigation for High Rise Buildings and a new course in how to interpret and apply the NEHRP Recommended Provisions for New Buildings.

In FY 88, FEMA will complete revision of its multi-year earthquake education plan which will define the scope of FEMA's earthquake training program for FY 89-93. This Plan will be incorporated into the revision of the NEHRP 5-Year Plan.

Other activities of interest to the Committee are: continuation of the seismic design workshops funded by FEMA through the American Institute of Architects/Association of Collegiate Schools of Architecture. Consistent with FEMA's philosophy that seismic design and construction represents the highest potential for earthquake hazard reduction, these workshops are intended to

stimulate interest and use of seismic considerations, including the NEHRP Provisions, among the private sector design professionals. In FY 87 and FY 88, FEMA will be convening workshops in the States of Missouri, Massachusetts, and a state-of-the-art workshop will be held in San Francisco. California. Jointly funded by the State of California, this workshop will incorporate the results of the emerging research from the Mexico City earthquake.

Finally, in this area, FEMA in conjunction with the USGS and NSF, will be holding a series of seminars this year which will look at how research results get applied and how successful have we, at the Federal level, been in promoting application of research at the State and local level. These will have a regional orientation and be held in San Diego, California; Denver, Colorado; and Knoxville, Tennessee.

The rare occurrence of noticeable earthquakes in the U.S. continue to make public education a challenge. FEMA believes the scientific facts exist to argue that earthquakes and the potential for damaging earthquakes are a nation-wide problem. Only through continued education efforts like those previously mentioned can we hope to reduce the effects of this lack of public recognition.

In closing, FEMA would like to emphasize that much progress has been made under the NEHRP to reduce the potential loss of life and property from earthquakes, but there is still much left to be done. We believe there is a need for a continuation of the strong research programs of NEHRP to provide new and improved scientific data as a sound technical base for all other earthquake hazards reduction activities. We do, however, believe that a portion of this research should be specifically targeted for applied or translated research. Specifically, this research should be targeted to solve a specific problem, such as existing building retrofit and the research should result in a useable product such as a handbook on how to retrofit.

Currently only a small portion of the NEHRP budget is devoted to this type of research. We believe that this applied research is critical for addressing the most pressing life safety problems associated with earthquake hazards reduction.

FEMA has a unique role in accomplishing the goals and objectives of the NEHRP. Not only as lead agency, but more critically as the primary agency working with State and local governments to translate research into actual implementation of earthquake hazard reduction actions. FEMA firmly believes the success of the NEHRP will depend on how well we, at the Federal level, have assisted States and local governments and the private sector in effecting earthquake hazard reduction programs.

Senator GORE. Well, thank you for being here. And we will hold off on questions until the panel has completed its testimony.

Our next witness is Mr. Doyle Frederick with USGS. And again, your statement will also be included in the record, and if you want to present portions of it, please proceed.

STATEMENT OF DOYLE FREDERICK, ASSOCIATE DIRECTOR, U.S. GEOLOGICAL SURVEY, ACCOMPANIED BY DR. JOHN R. FILSON, CHIEF, OFFICE OF EARTHQUAKES, VOLCANOES AND ENGINEERING

Mr. FREDERICK. Thank you, Mr. Chairman.

I am also pleased to appear before the committee to support the reauthorization of the National Earthquake Hazards Reduction program, and to comment briefly on the activities of the U.S. Geological Survey under this program.

Our written testimony has appended to it a budget justificiation, and I won't take the time at the moment to go through the justification.

It provides details of and justification for activity under the national program.

I might comment at this point, Mr. Chairman, that the U.S. Geological Survey earthquake program is a separate line item in our budget and is evaluated on a separate basis. It represents what we believe to be an excellent mixture of basic and applied research, and we go to great lengths to make sure that the results from our programs are provided to those who must make the decisions with regard to earthquake mitigation.

The program involves five components: monitoring and estimation of earthquake potential; earthquake prediction research; regional earthquake hazards assessments; distribution of earthquake information; and engineering seismology.

As mentioned earlier, this is the tenth year of our participation in the program, and we believe that a great deal of progress has been made in identifying and assessing the earthquake hazards of this country.

Specifically, we believe that the techniques for estimating earthquake potential along faults has been considerably enhanced. We have prepared a national seismic risk map that provides information on seismic risks throughout the country.

We have participated in regional hazards assessments in California and Utah and will have other programs of that type beginning in the near future.

And also, we've carried the earthquake information, again, to those that need to work with it.

And finally, we have taken earthquake prediction from the basic research category into a full-scale earthquake experiment in Parkfield, California, and I'll talk more about that in just a minute.

David McLoughlin mentioned the question of balance in terms of the program balance and approach. Let me comment just a minute on that from the Geological Survey point of view.

We look at the program requirements in terms of the basic objective of the legislation, and that is to pay attention to the causes of the earthquake; to prepare the basic research information; and to

translate that information into something that can be used to reduce the earthquake hazards.

And we think we have done a pretty good job in that regard over the past 10 years. I am speaking not just for the Geological Survey, but I think of the Federal agencies involved on this panel and in the program, and also in the area of the State and local government cooperation with the Federal agencies on this panel.

If you will permit me, I would like to spend just a minute talking about three program activities I believe relate specifically to the issue at hand, and that is, what are we doing and how well are we doing on this major matter.

The first example is the regional earthquake hazards assessment program, and I would like to take the Wasatch Front in Utah as an example.

During the period 1984-86, we worked closely with the State of Utah in a detailed analysis of the earthquake problems of the Wasatch Front, a region that includes the cities of Salt Lake City, Provo and Ogden, Utah, and on the remedial action that might be taken by the State and local officials to mitigate the hazards identified.

We worked with those officials in the project design, on the basis that results would be much more easy to deal with if the officials were involved from the beginning.

We are now at completion of the first phase of that program, and have provided information on earthquake hazards to the State and local officials.

We are now extending that cooperative study to a two-year implementation phase, and we think a great deal of progress can be made in that regard.

The next regional earthquake assessment will be in the Pacific Northwest, and we intend to work with the States of Washington and Oregon in accomplishing the same kind of thing.

The second example of our activities looks at the matter of applying earthquake prediction research in the field in a fully operational experiment.

In Parkfield, California, we are engaged, with the cooperation of the State of California, in a full-fledged earthquake prediction experiment. In this case, we expect a moderate, about a magnitude 6, earthquake in the next few years.

What we hope to be able to do is by careful monitoring of premonitory events to predict the earthquake if at all possible, and to learn from those premonitory signals what one might expect to see to be able to predict earthquakes elsewhere along the San Andreas fault and elsewhere in the country.

We have an extensive array of geophysical instrumentation, and that instrumentation is being closely monitored at this time.

We also have worked out with the emergency people in the State of California, and with the Office of Mines and Geology a fairly elaborate procedure for, one, cooperating on a technical basis, and two, notifying the local officials if we expect something to happen.

We have worked out, again, with our National Earthquake Prediction Advisory Council and with the California Earthquake Prediction Advisory Council, a rather elaborate decision tree that says,

if we see the following kinds of premonitory events, here are the kinds of information that we will pass along to you.

We think that is working very well, and we are optimistic about the results of that earthquake experiment.

Finally, during the last ten years, we worked actively with FEMA, with the other Federal agencies on this panel, and with the State and local officials to disseminate our research information.

Through a series of 20 workshops designed to explain how the scientific and technical results can be put to work in practice, we have involved local engineers, local officials, and emergency managers.

The workshops have been widely distributed geographically, and as you mentioned earlier, Mr. Chairman, many of those have been in the eastern part of the United States.

We have had workshops in Albany, New York; Nashville, Tennessee; San Juan, Puerto Rico; Charleston, South Carolina; Little Rock, Arkansas; Boston, Massachusetts; and St. Louis, Missouri.

And just to further comment on the matter of eastern earthquakes in the United States, it is true that one could expect over the next several years a moderate earthquake in the eastern United States.

And it is true also that there is perhaps a lack of awareness on the part of the people in the eastern part of the United States regarding earthquake hazards, and also, some lack of technical understanding of what causes those earthquakes.

I believe that a significant amount of attention is being paid to the eastern part of the country, and we will continue to do that.

I might just mention as one item there in terms of the Geological Survey's commitment to the eastern part of the country, the chief geologist of the Geological Survey has stepped down from his management position and has gone back to research, specifically looking at eastern seismicity and trying to understand the possibility for an earthquake in that part of the world.

Mr. Chairman, that concludes my oral statements, and I would be happy to answer questions.

[The statement follows:]

STATEMENT OF DOYLE G. FREDERICK, ASSOCIATE DIRECTOR, USGS, DEPARTMENT OF THE INTERIOR

Mr. Chairman, I am pleased to appear before this subcommittee to support the reauthorization of the National Earthquake Hazards Reduction Program and to respond to your questions regarding the activities of the United States Geological Survey (USGS) under this program. This fiscal year is the tenth year we have participated in the program, and during the year we shall spend nearly $34 million on work directed towards its goals.

During the past 10 years, we have made considerable progress in the basic understanding of earthquake phenomena, in identifying and assessing the earthquake hazards of the country, in the development of earthquake prediction systems, and in pursuing procedures to put the results of our work into practical application. A list of the salient examples of our work during the past 10 years would include:

Development of techniques for estimating the long-term earthquake potential of a fault.

Development and publication of national scale seismic risk maps that show the upper limit of the severity of ground shaking to be expected in 50-, 100-, and 250-year time periods.

Completion of regional earthquake hazards assessments in southern California and Utah.

Carrying earthquake prediction from a field of basic research to a full-scale experiment.

Many other examples exist although time does not allow us to cite them this morning.

Our role within the program during the past 10 years can generally be described by the term "applied research." The USGS is primarily a scientific bureau engaged in geological and hydrological research, natural resource assessments, the development and application of mapping techniques, and the publication of maps and reports based on our work. Within the program our role has been to support research with a clear link to reducing earthquake hazards, to publish and make known the results of this research, and to work actively with State and local officials in the application of these results. We have borne the responsibility of issuing statements on earthquake hazards, both long and short term, when we judged it was appropriate. We have provided scientific leadership in those areas that we felt needed stimulation or direction. Thus, we are comfortable with our role of bridging the gap between pure research and practical application. We feel this role is appropriate given our overall mission and organizational capabilities.

Specifically, our program is cast into five major elements: regional earthquake monitoring and earthquake potential estimation, earthquake prediction research, regional earthquake hazards assessments, distribution of earthquake data and information, and engineering seismology.

The details of the work proposed under these elements for FY 1988 have been reported previously to the Senate in the annual budget justification of the Department of the Interior. For completeness, we have appended a copy of the earthquake program budget justification to this testimony.

In FY 1988, we find it necessary to reduce our work in support of the earthquake program to support higher priority programs while holding the overall budget about on level with FY 1987. The budget reduction will be $2.2 million from the FY 1987 level and $4 million from the FY 1988 base of this program. These reductions will be taken in those areas of the program which we judge to be of lower priority when measured as having less of a chance of eventual "pay-off" or eventual application. We feel that our remaining effort, over $32 million, is adequate to meet our responsibilities in working toward the goals of the Earthquake Hazards Reduction Program.

During the past 2 years, there has been considerable discussion of program balance and whether the application of research results is commensurate with the level of research. I would like to elaborate on three examples, two of which were referred to briefly above, of our efforts to turn research into application.

The first example is in the regional earthquake hazards assessment element of our program. In 1984, we established a policy of focusing our earthquake hazards assessment work to provide more detailed analyses of earthquake problems and remedial actions for State and local officials. These analyses would be based on an intensive 3-year program in which new research and studies would be tailored to the needs of a particular region. The region chosen for the first effort was the so-called Wasatch Front of Utah, a region that includes the cities of Provo, Salt Lake, and Ogden. It was determined that chances of success of the effort would be increased if we could involve State and local government officials early on—make it their plan and give them a stake in the success of the plan. From the beginning of this project, we worked closely again with the Federal Emergency Management Agency, the Utah Geological and Mineral Survey, and the Utah Division of Comprehensive Emergency Management.

The results of the intensive scientific effort will be published in a major USGS report later this year. Although some implementation of these results and recommendations that arose from the 3-year effort have already taken place, we have decided to extend our support to the State for another 2 years (1987–1988) to enhance the local implementation effort.

We are continuing this program by beginning this year a 3-year period of intensive studies of earthquake hazards in the Pacific Northwest. In December 1986 and again last month, we held another of a series of meetings with officials from Oregon and Washington to plan the field work that will begin this summer.

Another example of application of research results is in our Parkfield earthquake prediction experiment. Parkfield is a small town in central California along a section of the San Andreas fault that is judged to have a high probability of a moderate earthquake within the next few years. The high probability of an earthquake there offers the opportunity to test many scientific and technical results and procedural mechanisms stemming from earthquake prediction work thus far. The fore-

cast of a magnitude 6 earthquake in the region was brought before and endorsed by the National and California Earthquake Prediction Evaluation Councils.

During the last 2 years, we have worked closely with the California Division of Mines and Geology and the California Office of Emergency Services to install geophysical instruments in the region, to bring the data from this equipment to data centers in Menlo Park and Sacramento where it can be analyzed continuously, to develop criteria for various alert stages based on this analysis, and to establish procedures for issuing warnings to the public.

Thus, starting from scratch 10 years ago, we have carried earthquake prediction through, with all of its attendant scientific and social problems, to a fully operational test in the Parkfield region. The regions of this experiment and lessons learned from it may have much wider application.

Our final example of research implementation involves the dissemination of information. During the past 10 years, literally hundreds of scientific papers, reports, and maps have been published through our efforts in this program. In the early years, we recognized the need to get the results of our work into the hands of the practitioners: the engineers, the State and local officials, and the planners and emergency managers—where these results could be put to use. We further recognized that just mailing reports to these individuals would not ensure that our results became known, let alone put into use. During the past 10 years, we have conducted 20 regional conferences or workshops, from Alaska to Puerto Rico-Virgin Islands and from New York to California, on earthquake problems within these regions and what may be done to mitigate these problems. Support for these workshops is often provided by the Federal Emergency Management Agency and other Federal and State agencies.

These, Mr. Chairman, are just a few examples of how we are carrying the results of research and technical work in a broad program through to implementation and application. With the reauthorization of this program, we shall continue to proceed aggressively in both research and application.

Thank you, Mr. Chairman. I would be happy to answer any questions.

Senator GORE. Our third witness is Dr. Nam Suh, assistant director for engineering at NSF. Dr. Nam Suh, please proceed with your testimony.

STATEMENT OF DR. NAM SUH, ASSISTANT DIRECTOR FOR ENGINEERING, NATIONAL SCIENCE FOUNDATION, ACCOMPANIED BY DR. JAMES F. HAYS, DIRECTOR, EARTH SCIENCES DIVISION; AND DR. MICHAEL P. GAUS, CRITICAL ENGINEERING SYSTEMS

Dr. SUH. Good morning, Mr. Chairman.

I am pleased to have this opportunity to discuss the Foundation's earthquake engineering and science research program.

With your permission, Mr. Chairman, I have a detailed written statement I would like to have included in the record.

In addition, I would also like to submit for your information a copy of our Program Announcement in Fundamental Earthquake Studies, a copy of a report describing our coordinated Masonry Research Program, and a report prepared by the RAND Corporation evaluating the Earthquake Hazard Mitigation program at the National Science Foundation.

The Foundation has both an earthquake engineering and a geosciences research program that are part of the nation's Earthquake Hazard Reduction Program.

In engineering, we are requesting a 10.6 percent increase for the earthquake hazard mitigation program for fiscal year 1988. This brings the total for the engineering part of the earthquake research to $16.5 million compared to $15.1 million in fiscal year 1987.

In geosciences, our fiscal year 1987 budget is $10 million, and our fiscal year 1988 request is $12 million.

Our goal is to help find ways to reduce losses from earthquakes, and to mitigate their effects. I will first review our program activities, and then discuss a number of special activities we have undertaken this past year.

The National Science Foundation's earthquake engineering research program is subdivided into four major areas including Siting and Geotechnical Systems; Structural Systems; Architectural and Mechanical Systems; and Earthquake Systems Integration.

The NSF engineering earthquake research support effort is aimed at; first, learning what happens when earthquake motions are transmitted to manmade structures; second, understanding the actual performance of structures and contents attached to these structures during an earthquake; third, finding ways to integrate and disseminate knowledge gained on earthquakes; and finally, strengthening earthquake mitigation and preparedness planning.

Our Siting and Geotechnical Systems program supports research on strong ground motions, stability of geotechnical systems, tsunami systems engineering, and lifeline systems, including roads, water systems, and so forth.

This first slide shows a building that has failed as a result of liquefaction, that is, a loss of strength of foundation materials, due to strong ground motions. We were fortunate to have had some strong ground motion equipment in place prior to the 1985 Mexican earthquake.

You can get some idea of the tremendous power of the earthquake from this slide, which shows the record of strong ground motions.

Structural Systems is another major research element. Here the research emphasis is on new and reliable design methodologies, computer simulation including the use of artificial intelligence, damage assessment methodologies, and again, lifeline systems.

This badly damaged building helps to illustrate the need for this sort of research thrust. Here we see a reinforced concrete building in which floor slabs have pancaked.

Our major program is Architectural and Mechanical Systems, which include research on nonstructural elements. An objective is to determine what needs to be done to retrofit existing structures to prevent their collapse during an earthquake.

This is a broad-guaged effort that looks at the impact of earthquakes on glass exterior cladding, elevators, building mechanical systems, power generation and transmission facilities, and the like.

Something we have wanted to accomplish for many years is the implementation of what is called base isolation. That is a situation in which the structure or equipment is isolated from the earthquake ground motion through the use of elastomeric bearings.

This slide shows a schematic of a bearing similar to the one that was used in California.

Our fourth area of research is Earthquake Systems Integration. This is to transfer research results to the user community.

Another key aspect of this program is research on earthquake mitigation planning; earthquake preparedness planning; and strategies for recovery and reconstruction.

In the Geosciences Directorate, research is supported to develop a fundamental understanding of earthquakes and the tectonic conditions necessary for their occurrence, and provide a basic scientific framework for programs in forecasting and prediction of earthquakes, ground motion predictions, and the like.

Several important research projects are underway. These include the Cajon Pass project in California, where deep drilling and instrumentation will provide important data as to earthquake mechanics.

In the Incorporated Research Institutions for Seismology, or IRIS project, the global seismographic network is being upgraded. This will allow us to image the interior of the earth and provide rapid determination of earthquake locations.

We have also issued a program announcement to encourage submission of proposals in the area of earthquake studies.

Here is a portion of Southern California showing the cities of Los Angeles and San Bernardino, California.

The prominent line stretching diagonally across the slide is the San Andreas fault. Just north of San Bernardino, and right alongside the San Andreas fault, is the site of the Cajon Pass scientific drilling project.

This is the drill rig at Cajon Pass which is just off Interstate 15. Drilling of a 16,000 foot hole near the fault is now in progress.

Seen in the next slide is the location of the drill hole relative to the San Andreas, and other small faults in the vicinity.

This hole will give us a close-up observatory located in a depth range where earthquakes are triggered along the fault. The project, when completed in 1989, will help us to understand the physical and chemical state of rocks near the fault, and the mechanics of the fault process itself.

Earthquake hazards are a national problem, as you stated, Mr. Chairman, not limited to Alaska and California, although the earthquake frequency, of course, is higher in these states.

Most of the foundation's research is generic in nature, and applies to earthquakes in general, wherever they may occur. Of the research that is related to a specific earthquake site, most is necessarily carried out in areas where earthquakes occur frequently, chiefly in California.

We do, however, also support research in areas where eastern earthquakes have occurred and on the general problem of intraplate earthquakes, the kind that occur not at the boundaries of crustal plates, but within the interior of the plates themselves.

Our COCORP Project, led by Cornell University, does about half of its seismic reflection profiling in the Eastern United States. This technique is well suited to locating deep seated fault structures that may not be exposed at the surface.

So far I have described our regular activities. Now let me describe a few special research efforts we have undertaken recently.

As you may know, 1985 was a catastrophic year with respect to earthquakes, both human lives and property losses. Both Mexico and Chile suffered tremendous losses of life and property from very strong earthquakes.

We took aggressive action to move research teams into these areas shortly after the earthquake to gather important data on

structure behavior and damage which would be lost if immediate action was not taken.

NSF is currently supporting 28 research projects in a coperative effort with Mexico. The Government of Mexico is supporting counterpart work, and these projects are well integrated.

It is a very productive cooperative research effort. Mexico's earthquake provided us with the following important insights and findings.

First, we have insufficient knowledge concerning the prediction of the quantity of energy which can be transmitted to sites a long distance from the earthquake epicenter.

Second, we need to understand the surface variability of strong ground motions and the need to carry out microzonation.

Third, current empirically based building codes and analytical techniques are inadequate.

Fourth, we need to consider structures and foundations as a system.

Fifth, we also need improved search and rescue techniques.

Sixth, we must develop quick and economic procedures to assess safety of existing structures.

Seventh, we need improved retrofit techniques for existing structures.

And finally, we must improve our understanding of human and institutional responses to large catastrophic earthquakes.

In other words, although we made much progress in the past, we have much to learn and innovate.

We are supporting eight projects on the 1985 Chilean earthquake. This research has been somewhat sobering for our investigators, because their theories do not always accurately predict the behavior of buildings during the earthquake.

For example, here is a building which apparently suffered foundation failure. However, on closer examination, this was actually a structural failure.

I want to emphasize that we are moving ahead very aggressively here at home with the efforts that are aimed at pushing the state of the art forward in all aspects of earthquake hazard mitigation.

We are very much concerned about whether there are significant problem areas in earthquake engineering which might be better understood through a more systematic research approach dealing with the totality of mitigation of earthquake hazards and the transfer of research knowledge to users.

NSF has recently, and after very intense competition, awarded a grant to the State University of New York at Buffalo for the establishment of an earthquake engineering research center.

The SUNY Buffalo team is an outstanding group of experts in this field. Also I should mention the State of New York is a full partner in this venture, and is providing equal matching funds, in addition to the facilities for the center.

Earthquakes, of course, are a potential problem for all areas of the United States, as you stated, Mr. Chairman. It is interesting to note that the largest historical earthquake in the U.S. occurred in Missouri in 1811–1812.

So in looking at earthquakes, it is important that we consider them in the context of a national program.

As I mentioned earlier, Mr. Chairman, the detailed statement we have provided for the record covers the breadth of our work and gives many examples of research accomplishment.

We believe that we have a very sound program for fiscal year 1988. It is national in scope and in vision, and if pursued aggressively in future years, it should make a real difference in our ability to mitigate the damaging effects of an earthquake.

This concludes my statement, Mr. Chairman.

[The statement follows:]

STATEMENT OF DR. NAM P. SUH, ASSISTANT DIRECTOR FOR ENGINEERING, NSF

Mr. Chairman and members of the subcommittee: Thank you for giving the National Science Foundation the opportunity to provide testimony on the reauthorization of the Earthquake Hazards Reduction Act. The earthquake research activities at NSF are conducted in both the engineering directorate and the geosciences directorate.

The earthquake research program is organized to provide proper principal agency input to the National Earthquake Hazards Reduction Program as detailed in the five year planning document. This planning document is updated periodically. The engineering directorate at NSF is responsible for the document objectives of seismic design and engineering research, and preparedness planning and hazard awareness. These two objectives include fundamental and applied engineering research, modernization of existing facilities, and societal response research. The geosciences directorate is responsible for the objective of fundamental seismological studies which includes implications of plate tectonics and the earthquake process.

The research program in the engineering directorate is designated as the earthquake hazard mitigation (EHM) program and supports fundamental research in engineering directed toward mitigation of the effects of earthquakes. The EHM program is a results-oriented program where the overall goal is to strengthen the existing knowledge base in earthquake engineering in order to minimize the loss of life and resources due to earthquakes. The earthquake engineering research program at NSF began in the early 1960's with a budget of less than one million dollars. The program grew steadily, and with the passage of the National Earthquake Hazards Reduction Program Act (1977), the program continued to expand to its current level of $15.1 million.

In the geosciences directorate, basic research is supported on the fundamental causes and conditions for earthquake occurrence including research on earthquake mechanisms, crustal movements, and seismology. The program has expanded to its current level of $10.0 million.

First let me provide a brief overview of the National Science Foundation's Earthquake Engineering and Science Research Program. Our research program is divided into five elements in two different directorates as follows:

ENGINEERING DIRECTORATE—SITING AND GEOTECHNICAL SYSTEMS

Research in this area addresses the fundamental engineering issues related to earthquake ground shaking and describes earthquake interactions on geologic structures including surface and subsurface soil and rock systems. The primary research areas are strong ground motion, stability of geotechnical systems, tsunami systems engineering and lifeline systems.

STRUCTURAL SYSTEMS

This program element supports research aimed at developing the capabilities to predict the behavior of structures during earthquakes, establish practical guidelines and methods for engineering design against earthquake loading, and provide economically feasible methods to strengthen existing hazardous structures. Some specific research areas are dynamic nonlinear systems, new and reliable design methodologies, computer simulation, knowledge-based computer systems, damage assessment methodologies and lifeline systems.

ARCHITECTURAL AND MECHANICAL SYSTEMS

Research in this program is focused on architectural and mechanical components and systems whose failure during an earthquake could result in loss of life, damage,

economic losses and social disruption. Examples are architectural and mechanical components in buildings such as glass and exterior cladding, elevators, building mechanical systems, power generation and transmission facilities, building contents, communications systems and masonry structures in which architectural and structural systems may be integral. Motion mitigation systems such as dampers, active control systems and base isolation devices are also considered.

EARTHQUAKE SYSTEMS INTEGRATION

This research supports research and related activities for the integration of knowledge-producing and knowledge-using systems. Key areas of research include earthquake mitigation planning; earthquake preparedness planning; impacts, recovery and reconstruction; and technology delivery.

GEOSCIENCES DIRECTORATE—EARTH SCIENCES DIVISION

This research develops the fundamental understanding of the tectonic conditions necessary for earthquake occurrences and provides a framework for earthquake prediction and hazard evaluation. Areas of research include plate tectonics, crustal structure, seismology, crustal deformation, and volcanism and landslides related to earthquakes. These subjects provide the scientific basis for more applied programs of earthquake forecasting and prediction, ground motion prediction, and the like.

Additionally, the EHM Program interacts with other programs at NSF. Other engineering programs which are coordinated with the EHM program are the Geotechnical Engineering Program and the Computational Engineering Program.

NSF also is a participant in the Interagency Committee on Seismic Safety in Construction (ICSSC). This provides the opportunity to coordinate NSF's research with the needs of other Federal agencies and the contributing agencies.

Since the mid-1970's, international competitiveness in earthquake engineering has become a global issue. This is a result of the international interest in construction and infrastructure projects, the disastrous impact an earthquake can have on the economy of a country, and the general desire for technical market dominance by certain countries. Since earthquakes are an international problem, there is a great deal of world wide interest in earthquake hazard mitigation. As a result, the relationship of NSF earthquake engineering research to the international business and political climate is important. Our research results are available in the literature and are used by foreign as well as U.S. industry in competing for engineering and construction projects throughout the world. Thus it is necessary that U.S. research be at the cutting-edge and that U.S. engineers (industry) take advantage of translating research results for application in a competitive environment. Hence, it is important that U.S. engineers be trained by U.S. universities and institutions to be able to accomplish this.

Since the EHM Program began, the accomplishments of the program have been many. Research projects have led to internationally-recognized new concepts and methodologies which have then been used in further development of earthquake hazard mitigation technology. A number of examples are:

A framework of understanding to explain liquefaction phenomena in soils subjected to strong ground shaking and an extension of this knowledge to predict liquefaction potential at various sites.

Deployment of research strong motion instruments and arrays to capture ground motion data both in the U.S. and abroad.

Development of special workshops and conferences to focus on the need for ground motion microzonation techniques and for completely new methods to characterize strong ground motion for engineering design.

Development of methodologies to investigate the effects of earthquakes on pipelines and buried lifeline facilities.

Studies to understand the mechanisms responsible for ground amplification of strong earthquake ground motions in soils at tectonic and engineering scales.

Initiation of a special effort to rapidly incorporate the latest developments in microelectronics or other fields into advanced instrumentation.

Support and development of 20 $\times$20 ft. 2-axis shaking table at University of California, Berkeley.

Participation in development of 12 $\times$12 ft. 5-axis shaking table at Suny/Buffalo.

Development of other specialized experimental research facilities such as 2-axis reaction wall at the University of Texas.

Development of ATC-3 model standard for seismic design of buildings and other structures.

Participation in significant international cooperative efforts such as the United States-Yugoslavia Program and the United States-Japan Programs on large-scale testing.

Support of basic research for implementation of the base isolation concept in the U.S. at the Foothill Communities Law and Justice Center, San Bernardino County, CA.

Development with industry of new methodology for retrofit to increase seismic resistance of unreinforced masonry structures.

Support of major coordinated research program aimed at providing rational knowledge base for reinforced masonry structures.

Research on and implementation of knowledge on design methods to improve seismic resistance of electrical transmission lines, generating facilities and electrical equipment.

Models have been developed predicting the degree of difficulty that can be expected in implementing certain types of mitigation strategies.

Key technical and managerial problems associated with the impacts and responses to earthquakes have been identified as a result of post-disaster investigations conducted in the U.S. and abroad.

Major principles of earthquake mitigation and preparedness planning have been determined and serve as the basis for action by such organizations as FEMA, the Southern California Earthquake Preparedness Project and the Central United States Earthquake Consortium.

An assessment of the fire potential following earthquakes in the U.S. has been completed and compared with the level of preparedness.

Comprehensive information dissemination programs have been supported including the National Information Service for Earthquake Engineering and the Natural Hazards Information Center.

A program of workshops and conferences have been developed for architects and other design professionals.

Selected seismic safety information programs in the United States have been studied to determine their effectiveness in achieving their goals.

The past fiscal year was a busy one for the EHM Program. Activities were driven by the occurrence of two large earthquakes and the importance in providing a systems engineering approach to earthquake engineering.

RESEARCH ON MARCH 3, 1985, CHILEAN EARTHQUAKE

The Chilean earthquake which occurred offshore of central Chile caused strong shaking in the coastal cities of San Antonio, Valparaiso, and Vina Del Mar, and inland to the capital, Santiago. An estimated $2 billion in damage occurred with 176 reported fatalities, about 2,500 persons injured, and thousands left homeless.

NSF supported a joint Earthquake Engineering Research Institute (EERI) and National Academy of Engineering (NAE) team which was immediately dispatched to Chile to capture perishable data. Based on this reconnaissance, EERI organized and held a briefing of the Chilean field investigations at the U.S. Geological Survey in Reston, VA, on July 18-19, 1985. Over 200 persons attended the briefing and heard reports on the seismological aspects of the earthquake; the performance of buildings, industrial facilities, bridges and lifelines; and reports on architectural, socio-economic, and health care aspects. Topics for future research in this earthquake were identified at the conclusion of the briefing.

As a result of the EERI briefing, research proposals were received and eight grants were made by NSF to perform research related to this earthquake which has implications for and application to earthquake engineering in the United States.

RESEARCH ON THE 19 SEPTEMBER 1985 MEXICO EARTHQUAKE

A major earthquake struck Mexico on the morning of September 19, 1985. Numerous buildings designed under building code standards comparable to those used in parts of the United States were severely shaken—both in the epicentral region along the Pacific coast and in Mexico City. In both areas strong motion instruments provided some coverage of the ground motions and of the effects of local soil and geological conditions upon these motions. There were many instances of collapse or severe damage of structures as well as many examples of excellent performance. Lifeline systems were put to the test. Emergency response procedures were severely strained. In short, this earthquake significantly tested earthquake hazard mitigation practices.

As part of NSF's existing programs, quick response teams assembled by the Earthquake Engineering Research Institute and the National Academy of Engineer-

ing were dispatched to the earthquake area to document highly perishable engineering information. A public briefing meeting on the reconnaissance work was held to discuss possible follow up actions required to maximize learning from the earthquake. This meeting was held in San Francisco and was attended by over 600 persons.

A joint panel was formed by the National Academy of Engineering and the Consejo Nacional De Ciencia Y Technologia (Mexican NSF) to prepare a report detailing potential research topics of importance. Unsolicited proposals were encouraged by NSF's Earthquake Engineering Program based on this report. NSF made 28 awards to U.S. investigators under this program. These projects are identifying lessons that can be learned from the Mexico earthquake experience that have relevance to mitigation and preparedness in the United States. The investigators are also working cooperatively with Mexican counterparts.

EARTHQUAKE ENGINEERING RESEARCH CENTER

In a problem focused area such as earthquake engineering it is very important to conduct research in an integrated manner using the systems approach. To accomplish this, NSF proposed establishing an earthquake engineering research center to supplement the traditional individual investigator approach and where earthquake hazard mitigation problems could be examined in a systematic interdisciplinary manner.

An Earthquake Engineering Research Center was competitively awarded to the State University of New York (SUNY), Buffalo in August 1986. The center is a cooperative $10 million per year research operation with NSF providing $5 million per year and the matching balance provided from State and non-Federal funds.

Although the award is to Buffalo, which will serve as a focal point for the center's activities, the new facility will involve the coordinated efforts of the City College of New York, Columbia University, Cornell University, Lamont-Doherty Geological Observatory, Lehigh University, Princeton University and Rensselaer Polytechnic Institute. The center will be directed by Dr. Robert L. Ketter, leading professor of engineering and applied sciences.

The center will conduct research to improve basic knowledge about earthquakes, engineering practice and the implementation of seismic hazard mitigation procedures to minimize the loss of lives and property. The center also will be a national focal point for earthquake engineering research and enhance the competitiveness of the United States through close interaction with the practicing engineering community.

Major areas of study initially will be directed toward buildings and other structures built before the need to mitigate the effects of earthquakes was realized. Another initial effort will be directed toward the earthquake risk presented by areas which could have a high intensity earthquake but with low frequency such as exists in the eastern United States. Emphasis will be given to a systems approach in which earthquake requirements are integrated with consideration of other hazards such as high winds and ground failures.

A BALANCED EARTHQUAKE ENGINEERING PROGRAM

In order to assure that the Research Program in the EHM Program is directed toward achieving the goals of the national earthquake hazards reduction program, NSF has recently completed an evaluation of the EHM Program. This was done by the Rand Corp. and the final report is in the process of being issued. Preliminary conclusions of this report indicate that the current EHM Program address the issues of importance in a balanced manner and that the past results of the program have been important to earthquake hazard mitigation.

SCIENTIFIC KNOWLEDGE BASE FOR MASONRY RESEARCH PROGRAM

A cooperative research project with Japan on the seismic resistance of masonry buildings was begun in fiscal year 1986. This activity is coordinated with a similar project by the building research institute of Japan as part of the continuing activity of the task committee on large-scale experiments of the panel on wind and seismic effects under the United States-Japan cooperative program in natural resources agreement. The U.S. Research Program consists of a series of coordinated research tasks beginning with those which address basic material behavior, progressing to tasks addressing behavior of masonry structural components such as walls, to experiments on a full-size research building.

Development of analytical methods for stress and strain analysis and system behavior will proceed in parallel with experimental tasks. The final task will be the preparation of recommendations for design procedures and building code provisions.

Completion of this 5 to 6 year program should result in the safe construction of masonry structures in all earthquake zones in an economic and competitive manner.

STRUCTURAL SYSTEMS LABORATORY

The Charles Lee Powell Structural Systems Laboratory at the University of California at San Diego was completed during the past year. It is a research facility for the experimental testing of full and large scale structural components and systems such as buildings, bridges, offshore structures, etc. NSF provided cooperative funding to assure that the design would accommodate the needs of the masonry research program which is coordinated with a parallel Japanese effort. NSF is also providing support to help equip the laboratory with hydraulic loading and data acquisition equipment needed to carry out the program.

A full-scale five story masonry research building will be tested in the laboratory in conjunction with the research program. With the San Diego supercomputer center located on the campus, this laboratory will have the unique capability to develop state-of-the-art interactive computer controlled structural testing procedures.

UPGRADE OF UNIVERSITY OF CALIFORNIA, BERKELEY EARTHQUAKE SIMULATION FACILITY

As part of NSF's continuing activity to upgrade existing earthquake engineering experimental facilities, significant resources have been awarded to the University of California, Berkeley to provide for advanced hydraulic-actuator equipment and controls. This will allow the earthquake simulator to be able to be used for more complex research problems.

GEOSCIENCES HIGHLIGHTS

At Cajon Pass, in California, a 16,000 foot hole is now being drilled alongside the San Andreas fault. This project, jointly supported by NSF and USGS, is designed to measure temperature, stress, and pore pressure within the depth zone where earthquakes originate. These data will be used to answer an important question about earthquake mechanics. At the completion of the project, instruments will be left in the drillhole to serve as close-up listening posts near the fault zone.

The COCORP Project (Consortium for Continental Reflection Profiling), led by Cornell University, and the Calcrust Project, led by the University of Southern California, are using the seismic reflection profiling technique, pioneered by the oil industry, to locate and map crustal deep faults that are not visible at the earth's surface. COCORP or Calcrust lines have now been run in 25 of the 50 States.

The University of Texas, working the USGS and using the methods of array seismology has developed a technique for imaging the rupture surface of earthquakes. This technique is a major step toward understanding how and why a particular earthquake occurred.

NSF has recently announced awards to 8 groups of university scientists to use the satellite-based global positioning system (GPS) to make precise measurements of crustal deformations in areas where active movements are now taking place. These measurements are expected to be helpful in locating areas where earthquakes are likely to occur.

IRIS (Incorporated Research Institutions for Seismology), a consortium of 50 universities representing 26 States, is working with the USGS to upgrade the global digital seismographic network. The primary purpose of this network is to make possible the imaging of the Earth's interior including the convecion currents that are believed to drive the motions of the crustal plates. In addition, however, this network will make possible the rapid detection and location of earthquakes anywhere on Earth and the prompt determination of source mechanisms to facilitate aftershock and Tsunami predictions.

The foundation has recently issued a program announcement designed to encourage submission of research proposals in fundamental earthquake studies.

IMPLEMENTATION

The NSF earthquake hazard mitigation program has made major contributions toward the goals of reduction of loss of resources and lives due to the occurrence of earthquakes. Future plans continue to be targeted toward changing technology and

changing user needs to assure that the U.S. remains in a leading competitive position in this field.

NSF will continue to disseminate research results to users and to cooperate with other relevant agencies in such activities. The dissemination efforts are aimed at diverse audiences, including engineers, architects, building officials, Government officials, and researchers. Numerous channels of communication are used to inform users of relevant research results. The Natural Hazards Information Center at the University of Colorado and the National Information Service for Earthquake Engineering at the University of California-Berkeley and the California Institute of Technology are central to this dissemination program.

In recent years, significant expansion has occurred in the knowledge base in the earthquake hazard mitigation field. As a result, new information systems are needed to facilitate the dissemination and utilization of research results in the area. NSF is supporting development of a prototype data storage and retrieval system for earthquake engineering and related earthquake hazard mitigation disciplines. In developing this system, the research is taking advantage of recent advances in the fields of memory technology, data compression, computer graphics and display technology. When completed, the system will allow for the wide dissemination of large volumes of textual and image data at an affordable cost to users.

Earthquake engineering is a global endeavor. It is important that U.S. designs and products be competitive on the world market. Therefore, research must be conducted that will make U.S. earthquake technology the leading technology which is also cost effective on international projects. As a part of this issue, participation in international programs needs to be continued and accelerated such that the U.S. can remain a competitive force in the international market. This includes taking advantage of any data that are generated because of the occurrence of foreign earthquakes for use in application to U.S. generated mitigation efforts. Cooperative research efforts are effective ways of achieving this.

SUMMARY

Since there is an active and competitive global interest in earthquake engineering, it is necessary that the United States lead the field in this technology. One technique for doing this is the rapid assimination of new technologies to the process of earthquake engineering research and practice. Examples would include microelectronics and better utilization of computers.

The EHM Program has, in the past, supported research on examining approaches to multihazard mitigation and preparedness planning and ways in which seismic safety planning can be integrated into general planning efforts and the consequences of such actions. This, and other mitigation and preparedness planning research, will be continued with a fast track toward implementation. This will be most useful to seismic safety engineers, architects, planners and design professionals.

New and innovative approaches to design and analysis need to be examined. The application of artificial intelligence and expert systems methods to mitigation and design is one advanced technology that can incorporate existing data and knowledge into the process. The EHM Program is aggressively supporting research advancing these new technologies.

I thank you for the opportunity to give a brief summary of the NSF Earthquake Engineering and Science Program activities.

Senator GORE. Thank you very much, Dr. Suh.

Our final witness on this panel is Dr. John Lyons, Director of the National Engineering Laboratory of NBS.

Welcome, Dr. Lyons, and your statement will also be in the record, of course, and please proceed.

STATEMENT OF DR. JOHN W. LYONS, DIRECTOR, NATIONAL ENGINEERING LABORATORY, NATIONAL BUREAU OF STANDARDS, ACCOMPANIED BY DR. RICHARD N. WRIGHT, DIRECTOR, CENTER FOR BUILDING TECHNOLOGY

Dr. LYONS. Thank you, Mr. Chairman. It is my pleasure to appear before this subcommittee to support reauthorization of this

program, and to describe the Bureau's efforts in regard to earthquake hazard mitigation.

We have two assignments under the legislation. The first is to provide technical support to the building community in continuing the developing, testing, and improving of model seismic design and construction provisions suitable for incorporation into codes, standards and professional practice.

The second is, to conduct a program of applied research in support of the first objective.

You inquired in your letter about the effects of proposed cuts on the Bureau's building technology program, and how they would affect the program on earthquake hazard mitigation.

I am pleased to tell you that the funding for this program within the Center for Building Technology will be level for next year, with or without the proposed cuts.

I would like to comment a little on our work with FEMA, and particularly, on the interagency committee on seismic safety and construction, as well as our work in support of FEMA's efforts with the Building Seismic Safety Council in the private sector.

We chair the ICSSC, and it is our objective to help Federal agencies reduce vulnerability to earthquakes. As noted in earlier testimony, we are concerned with new and existing buildings, as well as with lifelines. We published in February of this year guidelines, seismic design guidelines, for Federal buildings, a topic which is also the subject of the proposed executive order.

And I would like to submit this report, for the committee's information, with your permission, Mr. Chairman.

Senator GORE. Thank You.

Dr. LYONS. The proposed executive order has been balloted successfully by Federal agencies, and is now under consideration by OMB as to whether or not to submit it to the President.

We provide support to the Building Seismic Safety Council, which is a private sector activity, and have done so for nearly a decade.

FEMA issued in 1985 a formal publication of that work, which reflects a good deal of the Bureau's technical support.

We have also been helping FEMA with planning, particularly for its programs to identify existing hazards in existing buildings, and techniques for their repair. The same is true for our work on lifelines.

The Bureau does have a small program of research specifically directed at problems in earthquake engineering. We completed in Fiscal Year 1986 a study, a fullscale study, of the strength of masonry in sheer walls, which are important for resisting lateral forces in buildings subjected to shaking from earthquakes.

We worked first on unreinforced, hollow block walls, which would not do well in an earthquake, in order to obtain a reference data base. This will then be used for comparison when we do in this year similar activities for lightly reinforced masonry walls.

Results of these activities will be submitted both to the American Concrete Institute and the American Society of Civil Engineers, both of whom have standards activities related to masonry walls.

We also have a program in diagonally braced steel frame buildings, again at large scale in our test facilities. Here we are trying

to understand the stress distribution in the connecting plates in such construction.

Last summer we broke a large-scale bridge pier, some 5 feet in diameter and 30 feet in height, in the largest such testing facility in the Western world. We subjected this large bridge pier to stresses that we would anticipate would be encountered in an earthquake, and rocked it back and forth to failure.

It's a rather spectacular experiment, as you might imagine. We are going to do a second specimen this summer, and compare these results with model predictions, as well as one-sixth scale tests that we have done in the laboratory.

This work is supported by the Federal Highway Administration, the California Transportation Department, as well as by our own funds.

We have been, on behalf of our three peer agencies, carrying out a study of a national earthquake engineering experimental facility. This study was called for in a 1984 National Research Council report which recommended that we do a cost estimation for a large shake table, and, subsequent to that cost estimation, compare alternative ways of gaining the necessary data at fullscale.

So the four agencies here at the table decided to do a four phase study, to have NBS carry it out, funded by FEMA and NSF funds.

The first phase of this study, which we have just completed, was to define the research agenda for a large-scale testing facility over the next five years.

The report of this phase we have published in this document, which I also submit for the committee's consideration.

That, as I say, was phase one. It's a four-phase study, and we have to consider whether to go forward, based on these pieces of information, to decide whether or not the four of us wish to undertake the second, third and fourth phases.

Our program at the Bureau of Standards has long been coupled to the efforts in Japan, a country which is subject to severe earthquakes, via the U.S.-Japan Natural Resources panel on wind and seismic effects.

There is another meeting of that panel about to take place next month in Japan, and Dr. Wright will attend as cochair of that panel.

We are also active in the CIB and the French CSTB in the same areas.

The committee asked in its letter for the results of our study of the Mexico City disaster. The Bureau of Standards and the U.S. Geological Survey headed a team of investigators representing the very first such investigatory team under the Interagency Council on Seismic Safety in Construction.

They went down and worked at the site for some period of time looking at many of the damaged buildings, and discovered that, among other things, this was almost a carbon copy of an earthquake that occurred in Mexico in 1957. The principal phenomenon was resonance, that is, a magnification of the earthquake motion, particularly in medium height buildings

I would say, Senator, that this phenomenon is very similar to what one experiences in an automobile when the front end goes out of alignment. You know that when you get up to certain speeds,

typically about 50 miles an hour, small road vibrations are magnified, sometimes to the point of throwing the car off the road.

This is exactly what happened in Mexico City with magnification factors of five or six at least. It was particuilarly true for certain types of buildings of certain heights. It could happen here.

One of the recommendations in our report is that we have to take into consideration in the design of structures and in the building regulations geotechnical aspects of a building site, as well as of the frame and foundation of the building itself.

Furthermore, we learned that there were construction details that weren't good, faithful implementations of the design or of the code in Mexico; we always find that in a disaster—that there is some less than perfect work.

And finally, we found that there were some design problems in the upper stories of some of these tall buildings.

Our report on this is available, and again, I submit this as the third document for the committee's information.

This complete my formal remarks, Mr. Chairman. Thank you very much.

[The statement follows:]

STATEMENT OF JOHN W. LYONS, DIRECTOR, NATIONAL ENGINEERING LABORATORY, NATIONAL BUREAU OF STANDARDS, U.S. DEPARTMENT OF COMMERCE

Mr. Chairman and Members of the Subcommittee: Thank you for the opportunity to testify this morning on behalf of the National Bureau of Standards (NBS) to discuss the earthquake hazard reduction efforts at the NBS. These activities are conducted primarily by the Center for Building Technology and are an integral part of the NBS building research program. I am accompanied by Richard N. Wright, Director of the Center for Building Technology.

As the Nation's central physical sciences and engineering measurements laboratory, the NBS conducts research on performance criteria and supporting measurement technology for earthquake-resistant construction. Unique laboratory facilities support studies of the strength and energy absorption characteristics of structural systems. We develop methods to predict earthquake resistance during design, to assess resistance of existing facilities, and to measure properties of materials and systems.

The NBS provides technical support for the development, testing, and improvement of seismic design and construction provisions. These are incorporated in practices for Federal construction and are used in national standards and the regulations of State and local governments. The NBS assists and cooperates with other Federal agencies, the National Institute of Building Sciences, professional organizations, model building code groups, and State and local building departments. Although the NBS has no role in the promulgation or the enforcement of building standards or codes, the technical support provided for organizations that do develop them is an effective means of getting research into practice.

The National Earthquake Hazards Reduction Program (NEHRP) which resulted from the Earthquake Hazards Reduction Act of 1977 (P.L. 95-124) assigned NBS the following continuing responsibilities:

Provide technical support to the building community, including the Federal agencies involved in construction, "in continuing the development, testing, and improvement of model seismic design and construction provisions suitable for incorporation in local codes, standards (including Federal standards), and practices."

Perform "research on performance criteria and supporting measurement technology for earthquake resistant construction."

NBS has provided technical and administrative support to the Federal Emergency Management Agency (FEMA) which has lead agency responsibility for coordinating the national earthquake program. NBS worked with FEMA in establishing and supporting the Federal Interagency Committee on Seismic Safety in Construction (ICSSC) and in participating in the non-Federal Building Seismic Safety Council (BSSC) activities. These efforts have led to development of considerable resource ma-

terial for improving seismic design provisions for building codes and standards and practices for both private and Federal construction.

The ICSSC assists Federal departments and agencies involved in construction to develop earthquake hazard reduction measures for incorporation in their ongoing programs. The ICSSC, chaired by the NBS, currently is examining a number of problems of importance to the Federal Government, including developing seismic standards for new buildings, condition or performance assessment and providing for strengthening of existing buildings, providing seismic protection for lifelines, and coordinating the response of the ICSSC to damaging earthquakes. The NBS is providing technical support for these activities. The NBS chairs the ICSSC Subcommittee on Standards for New and Existing Buildings. This subcommittee developed seismic design guidelines for Federal buildings. The guidelines were approved by the ICSSC as its first recommended practice and published in February 1987. These guidelines are intended for consideration and use, as appropriate, by Federal agencies for the planning design and construction of buildings. A copy of the report entitled Seismic Design Guidelines for Federal Buildings, NBSIR 87-3524 containing the guidelines and a commentary is provided for the record with my testimony.

The ICSSC has successfully balloted a proposed Executive Order "Seismic Safety of Federal and Federally Assisted or Regulated Construction." The order defines what Federal agencies must do to meet the requirements of the National Earthquake Hazards Reduction Act of 1977. It has been submitted in February 1987 by FEMA for processing by the Office of Management and Budget.

At the request of FEMA, the NBS has provided technical support to the Building Seismic Safety Council's (BSSC) program on improving seismic design provisions for building standards and codes. The seismic provisions considered in this program were originally prepared by the Applied Technology Council in 1978 in a major project sponsored by the National Science Foundation and the NBS. The seismic design procedures developed by BSSC through a consensus approval process of the Council membership were published in November 1985. The three-volume document, NEHRP Recommended Provisions for the Development of Seismic Regulations for New Buildings has been printed by FEMA and widely disseminated. An update effort is now underway and due for completion in 1988. NBS is continuing to work with the BSSC in this effort through participation in the Technical committees that are developing the provisions and the oversight committee which is directing the project.

In most cases, the greatest danger to the population during a severe earthquake is that caused by buildings that were not designed for seismic resistance. We need to develop techniques to identify the most hazardous buildings. This work will include use of nondestructive test methods to determine the properties of buildings and their components in place, and various techniques for strengthening and repair. In Fiscal Year 1986, FEMA developed a comprehensive program plan to address this problem. NBS provided technical support to FEMA in this effort.

Subcommittee 1 of the ICSSC has begun work on developing procedures for identifying hazardous buildings. The procedures developed for use by Federal agencies are being coordinated with related efforts being conducted by BSSC for private sector buildings. NBS chairs the Subcommittee 1 effort and is providing technical support to the BSSC work. Roads, bridges, power distribution facilities and other lifeline structures are critically important in the post earthquake period. NBS is providing technical support to the FEMA effort to develop a program plan for addressing problems with lifelines. We will continue our participation in the program as it develops over the next several years.

NBS RESEARCH ACTIVITIES

The NBS earthquake research program addresses two problem areas: safe and economical new construction, and assessment and mitigation of hazardous existing facilities. The work concentrates on the most urgent research needs to fill the gaps in building codes and standards, to develop new criteria, and to make recommendations for repair and retrofit of existing structures. The research is conducted in close cooperation with other Government agencies, practicing engineers and architects, professional organizations, trade associations, building owners, product manufacturers, standards and regulatory organizations, and university researchers. These interactions assist in identifying and assigning priorities to research problems in earthquake engineering and ensure that NBS efforts are coordinated with other work.

Strength design of masonry walls to resist earthquakes has been identified as an area in which there is a serious deficiency of supporting research. Information is particularly needed for the design of reinforced masonry structures in the central

and eastern U.S. The NBS/Building Seismic Safety Council and others have indicated that research is needed to substantiate and improve the current code provisions for determination of shear wall resistance to earthquakes.

The first phase of an NBS research program begun in Fiscal Year 1984 was completed in Fiscal Year 1986. The program is aimed at defining the shear capacity and behavior of masonry walls. The first phase was devoted to unreinforced, hollow concrete block walls. The parameters studied included vertical compressive stress, wall aspect ratio (wall length to height), block strength, mortar type, and external flexural reinforcement. A total of forty-nine wall panels were tested. The wall panels were subjected to in-plane displacements in combination with vertical compression stresses using the unique NBS Tri-directional Test Facility (TTF), a computer-based test system. The results of Phase One will be incorporated into recommendations for the design of masonry wall elements and submitted to the Masonry Structures Standards Committee of the American Concrete Institute and American Society for Civil Engineers in 1987. In addition, the test results will serve as benchmark data for Phase Two involving studies of reinforced masonry walls. The reinforced masonry specimens are currently being fabricated and will be tested at NBS this spring.

Experiments are also in progress at NBS to study the behavior of connections in braced multistory steel frames. The program was developed in cooperation with American Institute of Steel Construction's Task Group on Bracing for Heavy Construction.

Multistory steel frame buildings frequently use a diagonally braced core to provide stability and to resist both earthquake and wind forces. It is common in such bracing systems to use steel plates (gusset plates) to connect the diagonal braces to the beams and columns. The force distribution in these plates and the force transmitted to the connecting members is complex and influenced by many factors which have not been experimentally verified.

Portions of a diagonally braced multistory frame or subassemblage are now being tested at NBS in the Tri-directional Testing Facility. Test boundary conditions will model those in the prototype building as closely as possible. The test specimens are about three-quarters of the size of typical buildings members.

Large-scale testing is an important component of the NBS laboratory work. Current work on full-scale bridge columns will extend understanding of the performance of very large structures and will provide data that are not currently available. One large-scale column 5 ft. in diameter and 30 ft. high, reinforced with 25 1.7-inch diameter reinforcing bars has been tested. This was the first full-scale laboratory test of this size to be conducted in the United States. The column was subjected to cyclic lateral displacements up to 2-feet while supporting vertical load simulating the weight carried by the columns. A second column of similar size is being fabricated at NBS and will be tested this spring.

A companion series of six one-sixth scale structural models have been tested to determine if research on small specimens can be safely extrapolated to the large sizes actually being used in bridges and to the large deformations expected in a severe earthquake. This work is being supported by the NBS, NSF, Federal Highway Administration (FHWA), and the California Transportation Department. The results of the one-sixth scale model tests have been reviewed by the California Transportation Department.

NATIONAL EARTHQUAKE ENGINEERING EXPERIMENTAL FACILITY

In 1984 the National Research Council published the results of its six-month study on "Earthquake Engineering Facilities and Instrumentation" requested by the Office of Science and Technology Policy (OSTP). One of the major recommendations of the report was that "The Federal government should undertake, on an accelerated basis, planning aimed at developing a major national earthquake engineering experimental/test facility. The goals of that facility should be to provide the data and understanding necessary for rapid improvement in the design and construction of seismic-resistant structures."

The first phase of a four-year feasibility study for a National Earthquake Engineering Experimental Facility was completed by NBS last month. The study, initiated by FEMA in accordance with the recommendation of the Science Advisor to the President, was funded at NBS during the first year by FEMA and NSF. A report has been prepared setting forth a five-year research program for a national facility in which full-scale or large-scale structures or structural components would be subjected to static and dynamic lateral loads. Representatives from a broad spectrum of professional, industrial and trade organizations, the National Research Council and Federal agencies participated in developing the research program. The proposed re-

search program will provide a basis for the remaining portions of the study. The Policy Coordination Group of the NEHRP will consider continuation of the study. Funding is not presently available. A copy of the report entitled National Earthquake Engineering Experimental Facility Study: Phase One-Large Scale Testing Needs, NBS Special Publication 729 is provided for the record with my testimony.

INTERNATIONAL ACTIVITIES

The U.S./Japan Panel on Wind and Seismic Effects provides for cooperative activities of 15 U.S. agencies and nine Japanese agencies and participating representatives of private sector organizations. NBS provides the U.S.-side chairman and secretariat. The Panel conducts an annual technical conference, alternating between the U.S. and Japan. The 1986 conference was hosted by the U.S. in Washington, D.C. to discuss recent research results. The results were presented in 21 U.S. papers and 20 Japanese papers. A one-week technical study tour of laboratories and construction projects followed the technical meeting. Five workshops are planned for the coming year. The Panel continues to plan for data exchange and cooperative investigation of earthquake mechanisms, ground motion, and structural performance in important Japanese and U.S. earthquakes.

Other international cooperative programs include:

A cooperative program with the French national laboratory for building research (Centre Scientifique et Technique du Batiment), which includes an information exchange project on seismic repair and retrofit of existing buildings.

Cooperative programs with Yugoslavia, funded by the U.S. Government, and administered by the Department of State, dealing with seismic design criteria, masonry shear wall resistance to seismic loading, bridge columns, and potential of soils to liquefy.

The International Council for Building Research, Studies and Documentation (CIB) facilitates international cooperation in research and improvement of building practices. Topics of structural safety, timber structures, actions on structures, wall structures and earthquake hazard reduction are particularly relevant to the U.S. earthquake hazard reduction program. NBS participates in these CIB programs as a CIB full member and through individual membership in working commissions and participation in CIB management. NBS also participates as a titular member and provides the U.S. Delegate to the International Union of Laboratories for Research and Testing of Materials and Structures (RILEM). RILEM has established a technical committee for international cooperation and development of test methods for seismic resistance of structures.

IMPLEMENTATION

The success of Federal programs for achieving earthquake hazards reduction can be measured in terms of the extent to which the results are used by various government agencies and private sector building owners and users and the extent to which the results are incorporated in new standards and improved design practices. The working relationships that NBS has established with groups throughout the building community provide channels for achieving this implementation. NBS building research staff participate actively in standards development in the private sector as well as at Federal, State, and local levels, with 44 different staff members involved with 175 distinct standardization activities.

These implementation and coordination efforts have resulted in the adoption of research findings in practice. For example, procedures being used by the engineering profession as a common basis for comparing results obtained from the Standard Penetration Test, a geotechnical engineering site investigation test method, are based in part on NBS earthquake research. This research also led to changes in the ASTM standard for the SPT test and to a new ASTM standard involving energy measurement techniques. NBS test results provide the basis for recommendations by the National Concrete Masonry Association to ASTM for modifying the details of the masonry prism test procedure. The California Transportation Department is considering modifications to their existing design procedures for bridge columns which would incorporate energy absorption concepts as a result of the NBS tests on full-scale and one-sixth scale model columns. The seismic provisions developed by the Applied Technology Council in the NSF/NBS sponsored project were used in developing the seismic risk map in the ANSI A58.1-1982 Standard, Minimum Design Loads for Buildings and Other Structures. Portions of the NEHRP Recommended Provisions are being considered by Committee 318 of the American Concrete Institute in developing the 1989 version of their Building Code Requirements for Reinforced Concrete Structures.

We conduct workshops for other Federal agencies on our earthquake research results and we participate in workshops put on by other agencies. As an example we have presented papers at workshops conducted by the USGS in the central U.S. and elsewhere.

Observations from post-earthquake reconnaissance surveys are an important source of information to assist in mitigating future losses. Following the September 19, 1985 Mexico City earthquake, a team of engineers and seismologists from the National Bureau of Standards and the United States Geological Survey was dispatched to Mexico City to provide technical advice to the rescue effort and to assess structural damage. The technical report from the investigation is in press; a preliminary copy is offered for the record. Many observations reiterate lessons learned in earlier earthquakes. The principal findings relevant to potential major changes in earthquake hazard reduction practices for the United States are:

Ground motions in the area of severe damages were greatly amplified by deep, soft soil deposits. Attention should be given to potential amplification of earthquake motions at such sites.

Collapses and severe damages occurred in some structures with natural frequencies in resonance with the frequencies amplified at the site. In some instances structures came into resonance as they softened with initial damages and then were more severely excited by the ground motions. Attention should be given to the effects of site conditions on the frequency-dependent earthquake intensity.

The duration of strong shaking was of the order of twenty cycles of strong shaking; this is more than is anticipated in current earthquake design practice. In areas susceptible to very large magnitude earthquakes, attention is needed to the duration as well as the amplitude of strong shaking.

Many buildings hit (hammered) adjacent buildings as they swayed during the earthquake and produced critical damages to buildings that otherwise would have performed well. Land use and building practices should provide adequate spacing to preclude hammering in earthquakes.

Rescue activities were hampered by the absence of heavy equipment for removing structural debris to reach persons trapped. The U.S. should be prepared to mobilize heavy equipment and skilled rescue teams following an earthquake disaster.

NBS is involved in communicating information on building performance to the engineering profession. NBS staff participated with engineers from Mexico City in a special session on the Mexican earthquake on October 22, 1985, at the American Society of Civil Engineers (ASCE) Annual Meeting in Detroit. The NBS presentation concentrated on the structural aspects of building performance, illustrated various types of building damage, and discussed causes of failure. NBS staff presented results of computer studies of buildings damaged in the earthquake at a special ASCE conference held in Mexico City on September 19, 1986 one year after the earthquake. They also worked with Mexican researchers in studying the dynamic response of damaged buildings and evaluating the performance of repair procedures. Information on the earthquake and on building performance collected by the NBS/USGS reconnaissance team has been compiled on video tape. Over 275 copies of this video tape have been distributed to Federal agencies, disaster preparedness groups at the state and local level, building officials, universities and design professionals. NBS also worked with the research community to plan an agenda of needed research.

This concludes my formal statement. I would be pleased to answer any questions you may have.

Senator GORE. Well, thank you very much. Before I start questions, I would like to recognize Senator Pressler, who is the ranking member of this subcommittee, for any comments he might want to make.

OPENING STATEMENT BY SENATOR PRESSLER

Senator PRESSLER. Thank you very much, Mr. Chairman.

I shall be very brief.

For several years I have been very interested in developing a continental scientific drilling program, and have introduced legislation in past Congresses.

My interest in this program occurred when Dr. Jim Papike visited me in one of my South Dakota field offices and convinced me of the practical effects of this program.

In this Congress I have introduced S. 52, which directs the Secretary of Energy, the Secretary of Interior, and the Director of the National Science Foundation to submit to Congress a report on the objectives, costs and benefits of such a program.

Continental scientific drilling has useful applications, not only for local mineral and energy deposits, but also in predicting earthquakes with greater accuracy.

Currently the National Science Foundation and the U.S. Geological Survey are drilling a three-mile bore hole several miles northeast of the San Andreas fault in California. Although the scientists have drilled only 6,000 feet, the results are promising.

The bore hole is providing scientists with much needed stress, fluid, and temperature measurements, and permits scientists to sample directly the physical properties of the earth's crust, where an earthquake could follow.

Just as importantly deep drilling permits scientists to test theories about earthquake formation developed in the laboratory against hard physical evidence.

Before this drilling began, scientists believed that significant heat and friction would appear at a fault line. That theory may be wrong.

Preliminary temperature readings from the drill site have not indicated that a signficant heat rise occurs at the fault line. Some scientists believe their initial theories may be wrong, while others believe that the heat is being absorbed by water flows.

Further drilling will solve this mystery and lead to new and useful theories about earthquake prediction.

A project like this proves that a national continental scientific drilling program could have a major impact on earthquake prediction and hazard reduction.

As the committee considers the reauthorization of this act, we should examine whether more needs to be done in this promising area.

I am very pleased to be here, and look forward to the testimony we are receiving this morning. I want to thank our witnesses.

And thank you, Mr. Chairman.

Senator GORE. Thank you.

I have just a few brief questions. Mr. Frederick, first of all, just yesterday afternoon, there was a 6.4 earthquake about 120 miles northeast of Tokyo, correct?

And all there were no reported deaths or significant damage, safety switches in three Japanese nuclear power plants were triggered, shutting them down, is that correct?

Mr. FREDERICK. As best we know, Mr. Chairman. We don't have full information on that aspect of the earthquake as of yet, but I believe that is correct.

Senator GORE. Anything briefly that you want to tell us about yesterday's quake?

Mr. FREDERICK. Let me ask Dr. John Filson.

Senator GORE. Only if there is some significant information to report.

Dr. FILSON. No, sir, we have nothing significant to report on that earthquake, but we should have in the next few days; we'll be happy to supply that to your office.

Mr. FREDERICK. Mr. Chairman, I might just say one thing.

With respect to the nuclear reactors, as you know, we do work with the Nuclear Regulatory Commission very closely in this country to look at concerns with regard to seismicity and nuclear power plants.

And as we understand, the nuclear reactors in Japan are equipped with safety devices similar to those which exist in this country, in which an automatic shutdown would occur at a certain level of ground shaking.

So we assume that that is the situation if those reactors did shut down.

Senator GORE. Since you mention the Nuclear Regulatory Commission, as I understand it, the NRC currently operates the earthquake instrument networks east of the Rockies, is that correct?

Mr. FREDERICK. Yes, sir, that is correct.

Senator GORE. And yet they plan to phase out their involvement, and you have expressed interested in taking it over, is that right?

Mr. FREDERICK. Yes, we have.

Senator GORE. Do you have any particular plans for them? Has the NRC been able to provide the approximately $5 million necessary for you to take over this program?

Mr. FREDERICK. Mr. Chairman, we have a signed memorandum of understanding with the Nuclear Regulatory Commission that provides for $5 million over a six-year period for development of advanced systems for monitoring earthquakes and to put into place about 70 stations in the eastern part of the United States.

We have half a million dollars provided by the NRC this year to begin that project. We are in a process of developing automated stations that will automatically collect the seismic data and transmit the information back to our Golden facility.

And we expect to test some of those systems yet this year.

Senator GORE. Well, we are going to hear from a witness on the next panel that the network you propose is going to fail to collect data on 90 percent of the eastern earthquakes.

They are low intensity quakes, but they are ones that tell us an enormous amount about seismicity in the eastern United States.

Is that true, you are going to miss 90 percent of them with this network?

Mr. FREDERICK. Let me ask Dr. Filson specifically to answer that question.

Dr. FILSON. I would have to look at the figures, Senator, to verify the 90 percent number. The difficulty is this.

The networks that are currently in place are focused on specific areas, some with high seismicity. They do not provide uniform coverage of the eastern United States in terms of geography. In fact, in some areas, there are no networks in place.

We estimate that the detection threshold of the new network will be approximately a magnitude of 2.5 to 3. It is true that, as the size of the earthquake decreases, say to 2 and magnitude 1.5, the number of those earthquakes significantly increases. The new net-

work will not detect those smaller events, and indeed will miss them.

Senator GORE. So you don't challenge Dr. Arch Johnston's figure of 90 percent, that you will miss 90 percent, you may miss well 90 percent of the events.

Do you challenge the assertion that these events are important to increasing knowledge about seismicity in the eastern United States?

Dr. FILSON. Any piece of data on earthquake location and size will increase our knowledge of earthquake hazards, and the earthquake occurrence rate in the United States.

Again, my point is that in some areas we are gathering no information at this time regarding these small events, and our judgment is that the uniform coverage of the eastern United States is as important as the detailed knowledge of specific areas.

Senator GORE. Well, it depends on what your purpose is. If you purpose is to pick up only the bigger quakes, and find out after one has occurred, that's one thing, and that has value.

But if your purpose is to learn about seismicity and improve our ability to predict quakes, improve our ability to deal with their consequences, then a network that misses 90 percent of the relevant events is not quite adequate.

I mean, I am just leaping to that conclusion. We will hear more about it from the next panel.

If you want to supplement your remarks for the record.

Mr. FREDERICK. Mr. Chairman, could I just make one comment at this point?

Senator GORE. Sure.

Mr. FREDERICK. It is true, I think, that with a national network, one might miss some events along the lines that you're describing.

And we do not expect that a national earthquake network would replace all regional networks. I think it is a matter of looking at the specific area, designing a scientific study that would let one conclude that I must see these kinds of events to be able to enhance our prediction capability, to understand the phenomena better.

So regional networks will still have a place, even with an overall national network. The question will be balance of funding and priorities, I would expect.

Senator GORE. Again, if you are going to miss 90 percent of the events that is disturbing to me.

Mr. McLoughlin, I referred in my opening statement to the estimate that if a very large earthquake struck Memphis, property damage might be in the range of $32 billion. How much progress have we made in preparing for a disaster of that magnitude in the ten years since we passed this Earthquake Hazard Reduction Act?

Is Memphis, for example, as prepared as it should be? Are its buildings safe? Are sound emergency procedures in place? And what is FEMA doing to help cities like Memphis?

Mr. MCLOUGHLIN. Mr. Chairman, the figures that you quoted in your opening remarks are indeed accurate from our perspective. They did appear in one of the reports that we did support.

I want to get directly to your question. But I ought to put it in the context that certainly earthquake preparedness is, on the west-

ern coast, particularly in California, it is much more advanced than it is other places. They did not reach that level of advancedness over night either.

The attention in the seven states in particular in the central U.S., to include Memphis and Tennessee, has only recently gained increased emphasis in the last several years. It will take time to make some improvements.

I think the direct answer to your question is no, Memphis is not as prepared as it should be. None of the states there are prepared. We do believe that the level of awareness that the earthquake hazard is increasing.

We do believe there are increased actions that are occurring, including databases that are being put together, including response planning activities that are occurring that are improving the preparedness. But there is still a way to go.

Senator GORE. Well now FEMA is the lead agency under this act and responsible for coordinating the activities of the government across the board. Correct?

Mr. MCLOUGHLIN. That is correct.

Senator GORE. But do you in fact have any authority over your sister agencies' earthquake programs?

Mr. MCLOUGHLIN. The direct answer to that question is no.

Senator GORE. You do not have any say in determining research priorities, you do not review proposed budgets from other agencies or ensure that overall research efforts matches the needs of the overall hazard reduction effort. Correct?

Mr. MCLOUGHLIN. That is correct. Mr. Chairman, the only place that the earthquake program of the four agencies comes together is basically before your committee, and before the similar committee in the House. We all have separate budget examiners. We all have separate appropriations committees. We all have separate constituencies from that standpoint.

Now it is true that we do, I believe, coordinate in several of the areas the research activities. For example, we did participate with the National Science Foundation in the selection of the research projects that are ongoing right now in Mexico City. But we do not determine the priorities for research.

Senator GORE. Okay, well that is an area that we may want to look at when we get to marking up this authorization.

Mr. Frederick, OMB is proposing to cut your program budget by $2.2 million. What exactly would you eliminate if Congress accepted that proposal?

Mr. FREDERICK. Mr. Chairman, a cut of that size would have us eliminate some regional earthquakes, primarily in the area of the outer fringes of——

Senator GORE. Well we are all for you eliminating some regional earthquakes. Maybe we can cut deeper.

Mr. FREDERICK. We would like to do that too. Our fiscal year 1988 budget will result in the reduction of earthquake monitoring regional networks in the Pacific Northwest, plus some along the Aleutian chain in Alaska. The other areas would——

Senator GORE. I imagine Senator Stevens will have something to say about that when the committee looks at it. Go ahead.

Mr. FREDERICK. The other areas would be some of our investigations. We will pull down some of the external investigative activity, but we will assure a balance between in-house and any external investigations. We will not reduce the external investigations disproportionately.

Mr. Chairman I might mention that that program is on the order of about $32 million as proposed for fiscal year 1988 in the program. And we still consider it to be healthy although the cuts are reasonably deep.

Senator GORE. Well, again we will have to look very closely at that.

Based on the information you now have, can you tell us, do you have the feeling that some areas are overdue, that some areas are more likely than others to have a large earthquake? We have heard a great deal about the San Andreas.

Mr. FREDERICK. I think our answer to that would be "yes," in certain parts of the country. Let me elaborate on that.

I mentioned Parkfield a little earlier. Historically, there has been a magnitude 6 earthquake in that part of the San Andreas fault about every 22 years plus, looking at the historic seismic record and the evidence in the geology. And we expect another magnitude 6 earthquake to occur in about 1988 plus or minus two or three years, so we expect one to happen there.

In the southern part of California we are concerned about the evidence that is being presented, both historically and in terms of the seismicity as well as the geology. The Director of the Geological Survey has asked the National Earthquake Advisory Council to look specifically at the southern California area to decide what we ought to be saying with respect to our responsibility for issuing earthquake hazards alerts for that part of the country.

For the mid-continent area of the United States at least, the statistical information would suggest that there is a probability of at least a moderate earthquake in that part of the world in the reasonably near future.

Senator GORE. Okay. Dr. Lyons, you said in your prepared testimony that the duration of the strong shaking in Mexico City was more than anticipated in current earthquake design practice. That struck me as an understatement.

Are you agreeing with those who say that Mexico City in fact had a state of the art building code, but that the problem was that the Mexican quake was simply stronger in some important ways than the engineers had anticipated when that code was designed?

Is that what you are saying, and if that is the case, what does that suggest about the adequacy of current building codes in the United States?

Dr. LYONS. Well I think it suggests that we need to review them. The number of cycles of shaking was much larger than one would normally expect; it was a very intense earthquake. I might ask Dr. Wright to comment on that, if he would.

Dr. WRIGHT. Indeed, as you have remarked, Mr. Gore, the earthquake duration of strong shaking was far beyond what we had planned our design criteria for.

So we need to be sensitive to areas of the United States that are exposed to very large magnitude earthquakes, because this goes

along with the duration of shaking. And we have to be sensitive to site conditions, which can tend to amplify the duration of shaking.

We should consider where appropriate that the cycles of strong shaking can be of the order of 10 or 20 rather than the current thinking which is the order of three or five.

Senator GORE. Now was this unique to Mexico City? I have been told that geologically there is an unusual condition under Mexico City where you have, I am on thin ice here so help me out, essentially a mud lake that causes the motion to translate into a horizontal back and forth motion that is more pronounced than in some other areas. Is that——

Dr. WRIGHT. Mexico City's siting conditions are unusual.

Senator GORE. Yes. I was actually in an earthquake in Mexico City one time.

Dr. WRIGHT. As you say, many people call it a bowl of jelly.

Senator GORE. Yes.

Dr. WRIGHT. It sits there in a saucer, filled in by lake sediments, so that you have very soft soils and you have potential focusing effects of the rock formations around the site.

So it is an extraordinary situation but we have many places in the United States where we build on rather deep sediments. So we must look carefully at the possibilities of very large earthquakes in these areas, and similar though not identical effects on the ground motions and the site amplifications.

Senator GORE. And the relevance of the duration of shaking for building design is that the frequency for certain building heights begins to build on itself so that the damage that can be done to the buildings is much greater as it continues because the waves increase in the structure of the building itself. Is that essentially what you are saying?

Dr. WRIGHT. That is part of it. And the other part is that you get some inelastic deformation with every cycle of the strong shaking.

Senator GORE. Yes.

Dr. WRIGHT. So that you can liken it to a boxing match. It is one thing to be hit by one right hand, it is another thing to be hit by five rights and five lefts in succession.

Senator GORE. Yes. All right. Mr. Frederick, in your workshops with state and local officials, have you been finding that they are receptive and more anxious to move forward with the recommendations that you all and others are making?

Mr. FREDERICK. Yes, Mr. Chairman. I think that is a fair characteristic of the reception that we have been receiving. I think that the reception has been better recently, probably because of the preparation that the Federal agencies and the State and local government agencies are doing prior to the earthquake workshops and perhaps also as a result of some of the events that we have discussed here today.

But we see a very good reception in all parts of the country. It is true that folks in California are probably more aware and are better prepared. But people in Memphis and Nashville and Knoxville and other parts of the mid-continent area are also beginning to be aware of the hazards and are willing to cooperate.

Senator GORE. Dr. Suh, based on your research, what kinds of structures pose the greatest threat to human life in the event of an earthquake?

Dr. SUH. Well it is generally well recognized that masonry buildings are the major threat to lives in terms of collapse of buildings. However, the research done in the past indicates that we can indeed reinforce existing buildings and even lower the cost of reinforcement by doing and applying the proper kind of research.

Senator GORE. The Mexicans have been working on a new computer modeling effort to better predict the impact on particular structures, Dr. Suh. Have we been working closely with them in providing supercomputer capacity? Are you familiar with that cooperative effort?

Dr. SUH. Yes, we do have cooperative effort and the details can be answered by Dr. Gaus, who is on my staff.

Dr. GAUS. Yes sir. We have a number of efforts in which we are trying to use supercomputers and other computing means to better be able to predict the transmission of energy to sites like Mexico City or sites in the United States. In addition, we are improving our capabilities to look at local anomalies of surface ground motion.

Senator GORE. Okay. Very good. I have gone over my time. Let me recognize Senator Pressler.

Senator PRESSLER. Let me first of all ask, what type of earthquake hazard studies require drill holes? To what depths?

Dr. HAYS. There are several reasons for using drill holes in earthquake research. Earthquakes normally do not originate at the ground surface, but rather at depths of several kilometers. It is then important to know the physical properties at that depth. The core pressure, the temperature, and the state of stress are some of these. The only way to directly obtain these and obtain samples of materials at that depth is through drilling.

Secondly, it is very useful to have instrumentation as close as possible to the source of an earthquake and also in a zone that is acoustically quiet, so that the signal to noise ratio is high. Placing instruments down a drill hole is useful for this purpose.

In fact, in the case of Cajon Pass project and at the conclusion of that project, the Geological Survey will instrument the drill hole as a down hole observatory.

Finally, drill holes are important to use as a calibration device for geophysical techniques. The Cajon Pass project is an example of a drill hole in an earthquake area that is useful for all these purposes.

Mr. FREDERICK. Senator Pressler, at the Geological Survey we share the NSF enthusiasm for the deep continental drilling program and its contributions to the earthquake prediction research and understanding of the earthquake phenomena, as well as to many other scientific endeavors that the Geological Survey would be involved in.

Senator PRESSLER. What are the specific benefits of conducting earthquake hazard studies by using drill holes? Is it cheaper or is it more accurate than let us say a seismic check?

Mr. FREDERICK. I would say that one would need a combination of information from a deep hole as well as seismic information in a

particular area. It turns out to be fairly expensive to drill a very deep hole, as you might imagine.

So we would use that money for the drilling purposes fairly cautiously and supplement that information with other information that might be available. Strain information of many types. So we would suggest a combination of techniques would be appropriate.

Senator PRESSLER. Tell me, in what ways do drill holes provide favorable environments for monitoring earthquake precursors? What hole depths are required and how long must monitoring be conducted?

Mr. FREDERICK. You may want a response both from the National Science Foundation and the Geological Survey. Start with NSF.

Dr. HAYS. I think a depth that would be interesting to monitor ranges from about five kilometers to as much as 15 kilometers. The deepest drill hole anywhere on earth right now is about 12 kilometers. So clearly it is not yet possible to monitor the deepest regions.

However, for depths of about five or six kilometers, which are well within present day technology, it is possible to probe into the zone where earthquakes originate.

Senator PRESSLER. As I understand the deepest hole that is drilled in the world is in Russia.

Dr. HAYS. That is correct.

Senator PRESSLER. What are they using their deep bore drilling for?

Dr. HAYS. They are still drilling. My latest information is that they are at about 12 kilometers now, and still going. The principal aim of that hole is to study the nature of the deep continental crust. The location is not in an earthquake prone region. They have been studying the fluids, the rock samples, and the properties at those depths within the deep part of the crust.

Senator PRESSLER. Should a scientific drilling program that addresses earthquake prediction be directed only to areas of known earthquake occurrence in the entire United States? And how would such a program be of benefit to nuclear power plant siting, missile deployment, underground nuclear test monitoring or civil defense?

Dr. HAYS. My answer to that would be that drilling is, as Dr. Frederick indicated, a very expensive process so that if you are considering drill holes aimed specifically at the earthquake question, I would certainly want to concentrate those in earthquake prone areas.

On the other hand if you are drilling holes for other purposes in other parts of the country, certainly the knowledge that you would obtain about the kinds of materials and the physical conditions there would also be useful for earthquake studies.

Mr. FREDERICK. We agree with that statement, Mr. Chairman.

Senator PRESSLER. What might be the cost of a long term research drilling program designed to understand and monitor earthquake occurrences? Of course it would depend on how many holes you wanted to drill and so forth and how big a program.

But a reasonable program that would give us some good information; what kind of money are we talking about? A few billion? As Everett Dirksen would say, real money?

Dr. HAYS. We are certainly not talking about billions. On the other hand, as you indicate, the cost of drilling is very sensitive to

the depth to which you want to drill. It is much more expensive as you go deeper and it is very much influenced by the rate at which you want to proceed. Do you want three or four holes a year or one hole a year?

In my opinion the program as it is developing right now is at a very appropriate rate and budget level.

Senator PRESSLER. Are there spinoff benefits that would help justify the costs of deep drilling?

Mr. FREDERICK. We think that the continental deep drilling program as presently conceived by the National Science Foundation, Department of Energy, and the Geological Survey is an excellent multi-purpose program to address many of the issues that we have discussed here today. And we, as I have said before, are very enthusiastic about that program.

Senator PRESSLER. This is a parochial question. Why do we not have any earthquakes, I hope we do not, in South Dakota, Iowa, or Minnesota? Maybe we have them but we just do not know about them. What is the reason for that?

Mr. FREDERICK. We do not have very many, and a simple response is that it is the nature of the geology.

Let me ask Dr. Filson to elaborate a little bit further on that.

Dr. FILSON. Senator, most of the earthquakes in the world occur along plate boundaries or margins.

Senator PRESSLER. Occur along what?

Dr. FILSON. Plate boundaries. I will try and explain that. The surface of the earth, the top hundred miles or so, is divided into about a dozen sections on the dimensions of hundreds of miles. And these are all drifting independently around the surface of the earth; when they collide, earthquakes occur.

As I said, 90 percent of the earthquakes in the world occur along these plate boundaries. There are no plate boundaries in your State. The nearest ones are along the western margin of the country—the San Andreas fault in California, and along the mid-Pacific rise.

Intraplate earthquakes, earthquakes that occur within the plates, usually are due to strain concentrations within the plate around certain geologic structures. This accounts for the earthquakes in the central Mississippi valley and elsewhere in the eastern United States.

The types of structures that tend to concentrate these strains are apparently lacking in your State.

Senator PRESSLER. That is why we should locate the super-collider there.

Senator GORE. I think your time is about up.

Senator PRESSLER. I have a question on insurance. A recently published Congressional Research Service report prepared for the Commerce Committee, "Earthquake Insurance: Problems and Options," found that while few persons purchase earthquake insurance, many are protected under other forms of insurance, fire or automobile.

A large earthquake causing billions of dollars of damage could, therefore, financially ruin most insurance companies. First of all, a question for FEMA, can you buy earthquake insurance if you live in San Francisco?

Mr. McLoughlin. Senator, I have with me this morning the deputy administrator of the Federal Insurance Administration, who is our most knowledgable person about this. And we asked him to come because we knew these questions would be asked.

Frank Reilly, would you mind answering that question please?

Mr. Reilly. In California currently, if a company has a homeowners policy they must offer the earthquake coverage. But the change in the California insurance marketplace has been another indicator to the industry for a need to address their problems.

Because there has been a developing concern in the meetings we have had with industry ad hoc groups that this type of offer acceptance is putting a strain on the local homeowners insurance market, and may lead to some aberrations in market availability of homeowners insurance. So that is in direct answer to the question.

Senator Pressler. Do you recommend that people have earthquake insurance in some parts of the United States?

Mr. Reilly. Yes I recommend it, but then——

Senator Pressler. Is it expensive?

Mr. Reilly. Yes I believe that insurance is a wise investment, particularly in California. I think there has been a lot of education that has gone on through, like I say, in California and FEMA's activities in these areas to make people more aware of the risks.

And I must compliment the committee on the report that I just recently received. It is an excellent report and it does bring together a vast amount of information that has been gathered over the years. You will find that knowledgable engineers themselves may not even provide insurance, but the Warden School has done many studies on that.

We find a tremendous sales resistance. Even though there is an available market, it's a very hard sell to the general public.

Senator Gore. If the Senator would yield briefly, on behalf of the committee I would like to accept your compliments on this report. But I must note for the record that it was requested by the committee and prepared by the Congressional Research Service and I would like to add my compliments to the principal authors, David Chaney and David Whiteman with CRS, who is here assisting the subcommittee again today.

But we appreciate your kind words, but the credit really should go to CRS, which often does excellent work.

Senator Pressler. Is there a need for any legislation as a result of this report, and your current assessment? Do you have any recommendations to be made?

Mr. Reilly. Well, we continue at FEMA to encourage the insurance industry to come to some consensus position. We think there has been a lot of progress made, particularly with the level of awareness that has been generated through the activities of FEMA and the various insurance study groups.

In connection with the action in California, although it may reasonably be concluded that its impact has been diminished greatly by the California Court of Appeals, it still is a great spur to the industry as to their potential vulnerability. The problem that we have come to realize in our own, it may sound anecdotal, but the Federal Insurance Administration does administer the National Flood Insurance Program. We administer the Riot Reinsurance

Program, and we currently administer the Federal Crime Insurance program.

We have in the past tried to design at a Federal level a recommendation of structures that affect the insurance marketplace. And it just has not worked. We have come, at least from our experience, to believe that you must generate within the private sector a buy-in to the concept.

When you are dealing with insurance, the major resources in this country, you deal in delivering the benefit. And that is in the post-disaster environment, getting claims paid, the only—there is a tremendous amount of ability for the industry to respond in that area—and that is industry response.

We have found, with our experience with the national flood insurance program, and our recent change in direction to reinvolve the insurance industry to the maximum extent possible, gets to that service end. It is delivering that benefit. It is coordinating the loss adjustment. It is moving the capital, you know, getting the resources to fund the reconstruction.

The menu of options that seem to be emanating from the various studies go way beyond at least the FIA's limited capacity even to model its impact. And when you deal with an insurance mechanism you deal with contractual obligation, you cannot size the scope of its course after the event. You have a contract to respond to.

Senator PRESSLER. Let me just ask one more question. And I thank you very much for your comments because they are very good. I know we have to move on.

This is a question for FEMA. As part of the fiscal year 1988 budget request, FEMA proposes to require states participating in the earthquake program to share on a 50-50 basis with the Federal government the costs of funding local emergency response and earthquake preparedness programs. FEMA believes that cost-sharing will lead to stronger state programs and institutionalization of these activities within state and local governments.

Critics, however, contend that FEMA's sudden announcement of this plan does not provide the states with sufficient time to appropriate the necessary funds and will result in the discontinuation of state earthquake programs.

How will cost-sharing increase state and local participation? Is there a possibility that states might discontinue their programs if they have to share costs? And would FEMA agree to a phase-in of the cost-sharing proposals till the states have time to appropriate the necessary funds?

Mr. MCLOUGHLIN. Senator, we recognize that there are some marked concerns on the part of the cost-sharing program. The first point that I would make is that that is roughly a third of our earthquake dollars. We would continue to fund mitigation efforts which ultimately find their expression in state and local governments as well, continue to fund those 100 percent.

But in terms of the pass-through dollars for preparedness activities state and local, it is our proposal to go to 50-50. We have had this under study for some time. We are cost-sharing and have cost-shared with the State of California since 1980. And we had expect-

ed to phase this in over a two or three year period of time in order to meet the budget cycles.

It is possible that we will miss some states. Some states might drop out. Particularly where people are not aware of the hazard as much as they might be, even in the central United States right now.

Given that, we do have a proposed rule on its way to the OMB right now for the clearance process. We do expect to get comments back in, and we will make every effort to minimize the impact on state and local governments.

Senator PRESSLER. Mr. Chairman, I want to thank our witnesses.

And I have to apologize. I have to go over to the Foreign Relations Committee where we are marking up a bill on nuclear enrichment to be shipped to Pakistan.

Senator GORE. All right, very good.

Let me just conclude this panel by quoting from the report on earthquake insurance that was cited in my opening statement and in the exchange just now.

The report says, some people are also concerned that the combined effects of earthquakes on the insurance industry and other parts of the financial system would lead to wide disruptions of the financial system.

The combination of insolvencies in the insurance industry, the liquidation of insurance company assets in order to pay claims, disruptions of the computer systems of financial institutions due to a quake, and defaults on mortgages due to uninsured damages could have a serious cumulative effect.

Little work has been done to analyze the likelihood or consequence of each of these factors, and it is difficult to assess the seriousness of a combination of them.

There are many other parts of this report that the committee would commend for careful reading by people concerned about this problem, but I did want to highlight that particular one.

Let me thank all members of this panel. We could usefully ask lots of other questions, but we must move on.

Thank you very much.

Our next panel has three witnesses, and I would like to invite them to come forward at this time.

Dr. Arch C. Johnston, Director of the Tennessee Earthquake Information Center at Memphis State University in Memphis; Dr. James Beavers, Martin Mariette Energy Systems, Y-12 Engineering at Oak Ridge; Mr. L. Thomas Tobin, Executive Director of the California Seismic Safety Commission in Sacramento.

All three of you are most welcome. Without objection, the full text of your prepared statements will be included in the record in full.

We will invite you to present summaries of your prepared statements as you see fit.

And we would like to begin at this time with the first witness on this panel, Dr. Arch Johnston, director of the Tennessee Earthquake Information Center at Memphis State University.

Dr. Johnston, welcome. Please proceed.

STATEMENT OF DR. ARCH JOHNSTON, DIRECTOR, TENNESSEE EARTHQUAKE INFORMATION CENTER, MEMPHIS STATE UNIVERSITY

Dr. JOHNSTON. Thank you, Mr. Chairman.

I appreciate the opportunity to appear before the subcommittee today. I will confine my oral remarks to the impact, and indeed, the control that the national earthquake hazard reduction program has had on university based seismological research.

This will be from the perspective of a university research scientist who is also involved in administration of a seismological research organization.

I will state my overall conclusion first.

Basic seismological research in the nation's universities is caught in a squeeze play which, if continued, will have a devastating effect on the quality of graduate education of the next generation of geoscientists, and the quality of basic research that is performed.

The factors contributing to the squeeze are diverse, but I would boil them down to the following three points.

The first is the severe downturn in the oil and energy recovery related industries.

Second, a perceived change of emphasis in the NEHRP.

And thirdly, the federalization of the seismicity monitoring networks, particularly in the central and eastern U.S.

Only the latter two points are germane to today's hearing.

The NEHRP has had many unquestioned successes and also some problems on which progress has been frustratingly slow. I outline some of these in my written statement.

More and more what I call big science projects are being undertaken under the auspices of the NEHRP in order to more effectively attack remaining problems in seismic mitigation.

I call these big science, but compared to a superconducting supercollider, or one percent of the national defense R&D budget, they are very, very small indeed.

These are projects such as the NCEER, National Center for Earthquake Engineering Research; IRIS, Incorporated Research Institutions in Seismology; DOSECC, Deep Observation and Sampling of Continental Crust; and the COCORP, the Continental Crust Consortium.

Please don't misundertand me. I applaud these programs, and want to see them prosper. I am attempting to involve my own organization in them to the maximum extent possible.

But at least currently, most of their funds are directed towards facilities, towards implementation and operation. Precious little translates into support for university investigators to train students, to think, and do research.

In the late 1970s, at the beginning of the NEHRP, a good research proposal in seismology to the NSF or USGS had about a one in two or perhaps one in three chance of full or nearly full funding.

Today the chance is more like one in five, or perhaps considerably worse.

Now I emphasize, these are not firm figures. They are from a very informal poll of the perception of some of my peers. I do know that at both NSF and USGS many high quality deserving proposals

that could advance our understanding of the earthquake process and seismic hazard reduction are rejected each year simply for lack of funds.

The final item I would address in my oral remarks is the transfer of control and operation of seismic monitoring networks from the universities to the Federal Government.

This greatly exacerbates the already difficult situation for the universities that I have alluded to. In the 1970s, in response to the need to obtain detailed and accurate seismicity data for the siting of nuclear power facilities, the Nuclear Regulatory Commission supported the installation and operation of a number of regional seismic networks in the central eastern U.S.

At least 18 networks were sponsored, of which 15 are operated by 12 universities. Now, the accumulation rate of seismic data from these networks, which is absolutely essential to any quantitative seismic hazard evaluation, is very slow; it is much slower than on the West Coast.

Decades of recording and analysis are necessary for fundamental progress in understanding the causative mechanisms and the spatial distribution of eastern seismicity.

The seismic monitoring networks, particularly in the east, have a reputation of being costly. They suffer from the perception of a poor cost-benefit ratio.

The reality is that one month's interest on one nuclear power plant alone, incurred because of a licensing delay caused by inadequate or ambiguous seismic information, would pay for the networks many times over.

The costs of keeping Diablo Canyon on hold for years, at least in part because of a lack of understanding of the seismic hazard at the site, would pay for and operate the networks for centuries.

An important related issue here: suppose we accept the premise that seismicity monitoring research in central and eastern United States is essential to effective seismic hazard mitigation, and to the long term energy requirements of the nation.

What is the best means to achieve effective seismicity recording and analysis? Perhaps the current university based regional networks are not the optimum solution.

Precisely this conclusion has apparently already been reached, with the scheduled phase-out of the NRC-supported networks by the early 1990s, to be supplanted by the Federal national network operated by the U.S. Geological Survey.

Seismicity monitoring would be transferred to the Federal Government, and the universities at best would have a small role to play.

Is this then the best overall solution? Obviously it is not for the universities, but the decision should not turn on that one aspect, but rather, on what is best for the seismic hazard assessment and mitigation for the country.

A national network would yield uniform coverage, which is the point Dr. Filson was making; standardized data format; wide dynamic range; broad frequency band; full waveform recording. Such a network is in fact in many ways superior to instruments currently operated by universities.

The USGS sets a high standard in technical and scientific excellence. All aspects of the proposed network, however, are not improvements over the current operation by universities. In my written statement I have detailed some of the more important technical drawbacks of the proposed network.

The 90 percent that was mentioned previously was from data for the New Madrid seismic zone, the highest seismic risk zone east of the Rocky Mountains, where 200 events are registered—average of 200—each year, and on average, only 10 or 5 percent of those are greater than or equal to magnitude 2.5, the minimum, estimated minimum locational threshold for the national network.

Also, the precision of the located hypocenters would be degraded. It would be difficult, more difficult, to relate earthquakes to actual faults or crustal structures, which is an outstanding problem in seismic hazard in the eastern U.S.

And the proposed data sampling rate is of less than optimum research quality.

There are two additional nontechnical drawbacks of this transfer of monitoring responsibility. These pertain to the universities.

The NRC funds provide crucial support for wide ranging research on continental crustal structure and tectonics, as well as provide core support for the training of the next generation of the nation's geoscientists.

Of and by itself, this support of university based education and activity perhaps is not a justification of a large monetary commitment, especially from an agency whose mission is regulatory in nature.

However, in the move to federalize seismic networks, geoscience programs at a dozen universities are being stranded. Their scope and quality will suffer significantly. And I believe that this is a fact that has not been taken into account in the proposed transfer.

A factor related to the above point is the involvement of the states in accepting some responsibility for seismic hazard and mitigation. The universities were moving in this direction, but by using Federal support as leverage.

For example, in my own organization, the Tennessee Earthquake Information Center of Memphis State University, the State of Tennessee now provides matching funds, matching the NRC support, in the amount of $2 for $1.

This important state commitment to the seismic hazard problem will be lost when the operation of the networks is transferred to the Federal Government.

The same is true, but perhaps to a lesser extent, for other universities in other states.

In summary, my appeal is this: In the drive to more effectively attack the difficult remaining problems in the earthquake hazards program, do not isolate the universities.

Pursue with vigor the large centralized programs, but also focus on reinvigorating individual university-based research.

Both are needed, and the proper mix will pay large future dividends.

Thank you.

[The statement follows:]

STATEMENT OF DR. ARCH C. JOHNSTON, DIRECTOR, TENNESSEE EARTHQUAKE INFORMATION CENTER, MEMPHIS STATE UNIVERSITY

Mr. Chairman, I appreciate the opportunity to appear before the subcommittee today. I believe my remarks will be of most value if I concentrate on giving an assessment of the impact—indeed the control—that the National Earthquake Hazard Reduction Program (NEHRP) has had on university-based seismological research. This will be from the perspective of a university research scientist who is involved in administration of a seismological research organization which also is responsible for public information and hazard mitigation activities for the State of Tennessee.

It is wrong to approach seismic hazard in the context of "solving" the earthquake problem. This simply is not going to happen, in the same sense that molecular biologists are not going to reach a "finish" in the study of the organization and function of life or physicists will not "finish" solving the structure of matter. What we reach for is a deeper level of understanding. In seismology and seismic hazard research, this goal has a dual requirement: (1) improved understanding of the basic physics (and chemistry?) of the earthquake generation process to the point that prediction is possible and (2) advances in understanding of the ways in which earthquakes threaten structures and the organization of society, so that better mitigation measures may be implemented.

Since 1977, the NEHRP hs become the primary vehicle by which the two previously-mentioned goals have been pursued by the American seismological and earthquake engineering communities. In today's hearing the Committee has heard of the administration of NEHRP and the progress and accomplishments under the program to date from representatives of the participating agencies. Let me try to supply a perspective from a participant at the university level.

First of all, there have been a number of unquestioned successes. We have learned to unravel the complexity of the fault rupture process, learned which avenues should be fruitful and which ones are not for the objective of earthquake prediction, and learned of the paramount importance of local soil and foundation conditions for seismic resistance of buildings. Great strides have been made in seismic preparedness in the West and to a lesser extent in the Central and Eastern U.S.; seismic hazard analyses of both the deterministic and probabilistic type are far more sophisticated today than 10 years ago; quantification of hazard at large critical facilities such as nuclear power plants is tremendously improved.

The list could go on; there is, however, a flip side that I think most seismologists and seismic risk analysts would acknowledge. This is in areas such as earthquake prediction, where, after much effort and expense, progress in real-time prediction has been disappointingly slow: large continental U.S. earthquakes still surprise us. Major uncertainties still exist as to the degree of seismic hazard and potential for damaging earthquakes in large sections of the country, particularly Central and Eastern U.S. Public perception of seismic risk is still, generally speaking, low, and preparedness measures (especially seismic requirements in local building codes) are still in their infancy in the East.

In response to the great quantity of new information gained from the first decade of NEHRP and in response to the many "unsolved" aspects of the seismic hazard problem it is my perception that the character of the NEHRP program has changed over the past several years. It has become more oriented to applications as opposed to basic research; it has begun stressing "big science" as opposed to individual research grants; prediction research has shrunk to focused experiments in the West; and the university-based seismic monitoring networks of the Central and Eastern U.S. are scheduled to be phased out and replaced by a federal national network.

The evidence supporting this change of emphasis is diverse. The big science aspect is represented by the NCEER [National Center for Earthquake Engineering Research], IRIS [Incorporated Research Institutions in Seismology] and DOSECC [Deep Observations and Sampling of the Continental Crust]. Research grants to individuals, mainly from the external research program of the USGS and from the Seismology Program of the NSF have become increasingly harder to obtain. I want to say that I do not have absolutely firm figures for this, but the general trend is accurate. The USGS funded less than a third of received proposals in FY87 and many of these were continuations. The most recent NSF seismology panel funded only 15 out of 71 proposals (21%). Additionally, the average grant size to individual researchers has been shrinking. Both agencies acknowledge that high quality deserving proposals are turned down each year for lack of funds.

The overall impact on university-based research in seismology and geophysics of these trends in the federal government coupled with the downturn in the energy exploration industries has been devastating. Most of the funding for IRIS, NCEER,

and DOSECC is for facilities and implementation; a much smaller portion translates into support for investigators to think and pursue individual research.

In the Central and Eastern U.S. (CEUS), an additional factor has come into play that exacerbates the already difficult situation for the universities. In the 1970's in response to the need to obtain detailed and accurate seismicity data for the siting of nuclear power facilities the Nuclear Regulatory Commission (NRC) supported the installation and operation of a number of regional seismic networks in the CEUS. The accumulation rate of these data—absolutely essential to any quantitative seismic hazard evaluation—is very slow in the CEUS and continuity is of key importance. Decades of recording and analysis are necessary for fundamental progress in understanding the causative mechanism and spatial distribution of CEUS seismicity. The seismic monitoring networks, particularly in the East, have the reputation of being costly—they suffer from a perception of a poor cost-benefit ratio. The reality is that one month's interest on one nuclear power plant loan, incurred because of a licensing delay caused by inadequate or ambiguous seismic information would pay for the networks many times over. The cost of keeping Diablo Canyon on hold for years, at least in part because of a lack of understanding of the seismic hazard of the site, would pay for and operate regional networks for centuries.

There is no guarantee, of course, that continued monitoring and analysis will satisfactorily clarify the seismic risk questions in the CEUS, nor is it absolutely certain that more nuclear plants, nuclear waste storage facilities or other high risk facilities will be built. But on the scale of decades, it seems practically inevitable. Given the many orders of magnitude differential between the cost of long-term seismicity monitoring and the cost of delays in power plant licensing and construction, it seems only logical and prudent to sustain the networks and the research through the period when a 'temporary' downturn in power plant construction makes such work unfashionable.

There is an important related issue here. If we accept that seismicity monitoring and research in the CEUS is essential to effective seismic hazard mitigation and to the long-term energy requirements of the nation, what is the best means to achieve effective seismicity recording and analysis? Perhaps the university-based regional networks are not the optimum solution. Precisely this conclusion has apparently already been reached, with the scheduled phase out of the NRC supported networks in the CEUS by early 1990's, to be supplanted by a federal national network operated by the U.S. Geological Survey.

The USGS national network would be capitalized by a transfer of funds from the NRC that currently are used to operate the mainly university-based networks. A proposed schedule is as follows:

Budget Profile in Thousands of Dollars

[Fiscal year 1987 dollars]

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
NRC	500	900	900	900	900	900	0
USGS	0	0	2160	2160	2160	2160	2160

Yearly Operating Cost after completion in Thousands of Dollars

[Fiscal year 1987 dollars]

Eastern United States	775
National network	1300

From the university perspective the net effect of this solution is this: at the end of year 6 (early 1990's) a USGS seismic network would be established and perform the functions of the university NRC networks which would no longer receive support. Seismicity monitoring would have become federalized and universities at best would have a small role (station maintenance?) and data access.

Is this the best overall solution? Obviously, it is not for the universities, but the decision should not turn on that one aspect, but rather on what is best for seismic hazard assessment for the nation. A national network yielding uniform coverage, standardized data format, wide dynamic range, broad frequency band and three-component recording is in many ways superior to the instruments currently operated.

All aspects of the proposed USGS network are not, however, improvements over the universities. I list below what I consider some of the more important drawbacks.

(1) The national network with fewer, more widely-spaced stations will have an event locational threshold of about magnitude 2.5. In a CEUS region that is currently well monitored, this amounts to missing over 90% of the seismicity. For example, in the New Madrid seismic zone, monitored by Saint Louis University and Memphis State University networks, an average of 200 events are registered and located each year. On average only 10 events or 5% equal or exceed magnitude 2.5. Of course this 5%, being of larger magnitude, is of more importance, but much high quality, important science has been and can be done by proper analysis of the smaller but much more abundant earthquakes.

(2) The precision of the located hypocenters will be degraded and uncertainties will increase in many regions of the country. Even with 3-component data and full waveform modeling, the much more dispersed station spacing (roughly speaking 200–300 kilometers versus 50 kilometers within regional nets) will hamper location, especially for smaller events, and most critically for depth. Accurately determined depths are essential to the very difficult and very important problem of relating earthquakes to subsurface faults or other features in the CEUS.

(3) For reasons of economy, the proposed digital sampling rate of the national net is 40 samples/sec. This has the effect of limiting data usefulness to frequencies below 10–20 hertz. Many important seismological questions and questions of engineering significance depend on higher frequencies than this. Many university networks currently digitize at 100 samples/sec or more. The 40 samples/sec rate will monitor seismicity but will curtail important research avenues.

(4) As of about 1985 the Nuclear Regulatory Commission funded 18 regional seismic networks of which 15 were operated by 12 different universities. In addition to providing study and monitoring of the nation's earthquakes, these funds provide crucial support for wider ranging research on continental crustal structure and tectonics as well as provide core support for the training of the next generation of this nation's geoscientists. Of and by itself, this support of university-based education and activity perhaps does not justify a large monetary commitment, especially from an agency whose mission is regulatory in nature. However, in the move to federalize seismic networks, geoscience programs at a dozen universities are being stranded. Their scope and quality will suffer significantly, a fact that I believe has not been taken into account in the NRC–USGS transfer.

(5) A related factor to (4) is the involvement of the states in accepting some responsibility for seismic hazard assessment and mitigation. The universities were moving in this direction but by using federal support as leverage. For example, in my own organization, the Tennessee Earthquake Information Center of Memphis State University, the State of Tennessee provides matching funds for the NRC support in the amount of two dollars for one. This important state commitment to the seismic hazard problem will be lost when the networks are federalized.

To summarize and conclude my remarks, the seismic hazard problems facing this nation are serious and will only assume more importance in the years to come as population and critical facilities increase. The NEHRP can effectively reduce seismic risk (not eliminate it) but needs a redoubling of effort at both the federal and university/state government level. An important component of the NEHRP is seismic monitoring networks, and this component is scheduled for a fundamental change—transfer from university to federal government control and operation. Such a change entails some benefits, but as pointed out here, it also is accompanied by some serious drawbacks, especially for the long-term health and vigor of university geoscience programs. It is not at all clear that the overall benefit will outweigh the overall drawbacks. Other avenues, such as regional network upgrade and centralizing university network operation under one or two data management and analysis centers as suggested to the House Subcommittee on Science, Technology and Space in the 1985 hearings on the Mexico City earthquake might be more effective in terms of both science and costs.

NOTE: Some of the suggestions and recommendations discussed in this statement as well as a number of others, are contained in the Seismic and Engineering Research Resolution issued by the Central United States Earthquake Consortium (CUSEC) on November 18, 1986. CUSEC is a FEMA-sponsored consortium to promote interstate emergency response and seismic hazard assessment and mitigation in the seven states vulnerable to a large New Madrid seismic zone earthquake.

Senator GORE. Thank you very much. We will pursue that in questions.

Our second witness is Dr. James Beavers with Martin Marietta Energy Systems. We welcome you, Mr. Beavers. And without objection, your full statement will appear in the record, and we invite you to proceed as you wish.

STATEMENT OF DR. JAMES E. BEAVERS, MARTIN MARIETTA ENERGY SYSTEMS

Dr. BEAVERS. Thank you, Mr. Chairman.

It is also a pleasure for me to be here this morning to support the earthquake hazards reduction program reauthorization.

I have addressed several issues on this subject in my written statement, but this morning, I want to focus on the state of science and engineering, primarily in the earthquake industry as it relates to the current international events, and the United States, especially the eastern United States.

After disastrous earthquakes in Turkey, Nicaragua, Yugoslavia, Romania, Algeria, Italy and Greece in the 1970s and early 1980s, the United States' engineers and scientists represented the leading foreign country visiting these disaster areas to help with aid and to assist with recommendations to prevent reoccurrences of such disasters.

In addition, we reap the benefits of these investigations by learning more about earthquake hazards, mitigation and engineering applications for this country.

However, in Mexico City in 1985, when 30 engineers and scientists from the United States went down to study the aftermath, they were joined by over 60 Japanese.

Here are some items that give me concern.

On September 19, 1986, on the anniversary of the Mexico earthquake, Professor Roberto Meli, of the National University of Mexico, was quoted as saying: Studies used in developing the new code were done in Mexico, though the group incorporated developments from other countries, especially Japan.

He was further quoted as saying, the Japanese have studied this much more deeply than engineers of other countries.

In the recent San Salvador earthquake, instrumentation that had been paid for and installed by Americans recorded crucial earthquake data. This raw data came very close to being given to the Japanese, and would have been had it not been for the influence of an American engineering visiting at the time.

At the 8th World Conference on Earthquake Engineering held in San Francisco in 1984, the Japanese had the number one foreign participation, with over 300 attendees.

Mr. Ed Keen of the Bechtel Corporation stated that one of the major high technology areas where the Japanese had the leading edge over American firms in world competition for work is seismic building design methods.

Dr. Akio Watatani of the Ohbayashi Corporation stated that their company spent $25 million on research in 1986, and they have 187 fulltime staff of researchers.

And I am told that the Kajime Corporation has approximately 400 persons on its research staff.

The Chinese are not far behind the Japanese. At the Institute of Engineering Mechanics in Harbin, they have approximately 400 personnel doing earthquake engineering research; and at the Academy of Building Research in Beijing, they have 1,200 personnel, and most are involved in earthquake research.

The two largest earthquake shaking tables in the world are located in Japan and the USSR, each having testing areas of 225 and 900 square meters respectively, while the largest table in the United States is only 37 square meters.

The last table that was built in the United States came on line in 1980, and there are no plans for others. In contrast, since 1980, the Japanese have built 14 tables.

Other countries including Germany, China, the USSR, Romania, Italy, France, Yugoslavia, Greece, and even Algeria, are increasing their earthquake capability.

The advisory panel for the national earthquake engineering experimental facility has recommended that this study must go forward. Unfortunately, the advisory panel has been told that funds are not available to continue such a study.

I submit to you, Mr. Chairman, that lack of research and development funding is one of the root causes of this country's decline in the international marketplace, and our ability to be more effective in the earthquake industry at home.

It is my opinion that the earthquake industry has fallen from its world leadership position like the automobile industry and like the steel industry.

In order for the earthquake industry to regain its leadership role, more nondefense R&D is going to have to be infused into the overall earthquake programs.

As I pointed out in my written statement, with its heavy population, concentration of energy distribution systems, lack of frequent earthquakes as a reminder, and relative seismic quiescence in the 20th Century, the eastern United States is a sleeping giant to be awakened by the unexpected.

Regardless of whether the future earthquakes of this country occur in the east or west, it is imperative that as a country we be prepared. It is my opinion that unless extraordinary effort is put forth in the next decade in mitigation, research and development, our citizens will continue to be like sitting ducks.

For sure, Japan, China, Algeria and others are taking action.

A possible solution may be for this country to mandate a national decade of preparedness, technological assessment and development.

Regardless, we must continue to support the preparedness projects. The Central United States earthquake consortium; the Southern California earthquake preparedness project; and others, so that our disaster preparedness activities are strengthened.

We must upgrade our existing testing facilities, and we must be bold about the development of new large scale testing facilities.

We need to develop better methods of assessing earthquake hazards. We need to know how to engineer structures for control damage. And we must develop better methods for strengthening old, hazardous buildings, especially our school buildings, which house 40 million school children everyday.

And we must push forward in the many avenues of research and development.

An increase in nondefense research and development funding must occur in science and engineering, and the earthquake industry must experience its fair share of these increases because we need a greater effort.

There is no real reason why we cannot have a seismic building code for the east. There is no reason why we cannot be prepared for that inevitable event.

And there is no reason why we cannot still be number one in the world of scientific and technical leadership.

We are not only in a natural hazards race with Mother Nature, but we are in an economic hazards race with other countries of the world, and we cannot afford to lose either one.

Following the course of the President of the National Academy of Sciences Dr. Frank Press' challege for an international decade of hazard reduction at the 8th World Conference on Earthquake Engineering in 1984, in the next decade of the national earthquake hazards reduction program I would challenge this country and its engineering and scientific professions to a national decade of preparedness, technological assessment and development.

Thank you.

[The statement follows:]

STATEMENT OF DR. JAMES E. BEAVERS, MANAGER, CIVIL AND ARCHITECTURAL ENGINEERING, MARTIN MARIETTA ENERGY SYSTEMS, INC.

Mr. Chairman and Members of the Subcommittee: It is a pleasure for me to appear before the Subcommittee on Science, Technology and Space in support of the reauthorization of the Earthquake Hazards Reduction Program. My strong interest in this reauthorization is a direct result of my current membership on the Committee on Earthquake Engineering of the National Research Council of the National Academies of Sciences and Engineering; my current Chairmanship of the Advisory Panel to the "Administration's" feasibility study on a National Earthquake Engineering Experimental Facility; my recent service as a member of the National Science Foundation's Advisory Panel for Critical Engineering Systems; my concern about the rapid slippage of this country's world leadership role, not only in the manufacturing sector of which we are all painfully aware, but in the service sector of the engineering and scientific professions—the threatening loss of our global, technical leadership, which has great implications on this country's ability to continue to compete in the international marketplace and remain a strong economic country; and most of all my concern for the life safety and welfare of the citizens of this country.

This morning you have heard a number of testimonies that have expressed the need to further pursue the social and technological fields of earthquake hazards, earthquake engineering and earthquake preparedness, areas that I prefer, if you will, to lump together and refer to as the "earthquake industry". It is a fact that if the scientific and engineering professions are to make advances toward reducing the loss of life of our citizens and damage to our industries and our cities when destructive earthquakes occur, we must have a strong program for providing implementation of mitigation activities and for understanding through research and development. Without continuing our research and development while we are implementing the mitigation actions that we currently know are feasible, we will be being shortsighted of the future and this shortsightedness will exacerbate this country's continued decline in the international marketplace, and in the long term negatively impact the life safety and welfare of our citizens.

During the preparation of my remarks I was asked by the Subcommittee Staff to address the issues of building codes in the east, seismic standards for lifelines, the state of geologic and seismological understanding to allow effective engineering design of critical systems, the seismic vulnerability of energy distribution systems in the east and the general state of science and engineering. While I will briefly address these issues, and you have already heard presentations on these issues by

others this morning, I want to focus my testimony on a specific issue that is related to the general state of science and engineering which was briefly addressed by the National Science Foundation—the issue of our international competitiveness, not only as it relates to the "earthquake industry", but the implications to other areas of science and engineering and the implications of what the current international events in engineering and science mean to this country in the long term.

To begin, the issue of building codes has been a complex one and the engineering profession, although it has been unified on the need for the adoption of seismic design requirements, has been divided on the specific technical approach that should be adopted. This is not an unusual situation in any highly specialized profession, however, without a unified accepted approach by the engineering profession the support to push for the adoption of such a code will not be forthcoming. This lack of unification has been particularly acute in the area of whether geographical areas east of the Rocky Mountains, where damaging earthquakes are infrequent, should adopt the same technical requirements as has been done west of the Rocky Mountains, especially the state of California, where damaging earthquake occurrences are relatively frequent. It is believed by some that if the east were to adopt the seismic requirements of the west it could cause overly conservative designs in the east and result in significant increases in construction costs. During the past ten years much work has been done in studying the seismic building code issue and I believe considerable success at understanding the problem and progress has occurred.

Through the laborious voluntary effort of many engineers around the country under the auspices of the Applied Technology Council, universal tentative seismic design provisions were developed in the 1970's and published with the support of the National Science Foundation and the National Bureau of Standards. Since that time the Trial Designs have been conducted by the Building Seismic Safety Council and funded by the Federal Emergency Management Agency to study the cost implications of a universal seismic design approach to various areas of the United States. Finally, the Federal Emergency Management Agency has published the "NEHRP Recommended Provisions for the Development of Seismic Regulations for New Buildings". In addition, two areas in the east have adopted some form of a seismic building code—Boston, Massachusetts and Charleston, South Carolina and, Mr. Chairman, I am happy to tell you that the City of Memphis and Shelby County, Tennessee have a committee to examine the adoption of a similar code. Although these efforts represent major milestones toward developing a model code for the east, I will not dispute the fact, that to be fully effective in adopting the best principals of seismic design for and throughout the east that further work may be needed. However, Mr. Chairman, I contend that technology does exist, although it may not be perfect, for a model code to be adopted in the east. I further contend that if regions of the east would utilize the current seismic design provisions that exist in the Uniform Building Code, for example, regardless of how applicable they may or may not be, then those structures designed for seismic forces will perform much better when subjected to a major earthquake than those that are not. In this case, Mr. Chairman, I believe "something is better than nothing" and right now "nothing" is the current state in many regions. Unfortunately, the adoption process of such codes gets bogged down when vested interests become involved.

Seismic standards for lifelines, I believe, is as complex an issue as the adoption of building codes and in many cases building codes can be used for lifeline standards. Lifelines include airports, oil and gas pipelines, electrical generating plants, dams, bridges, railroads, water supply systems, sewage systems and telecommunication systems. Today, I know of no consistent use of seismic standards for lifelines east of the Rocky Mountains except for nuclear power plants. However, to adopt the same seismic design requirements for other lifelines as are used for nuclear power plants would be extremely conservative and would not be cost effective. Certain standards for lifelines have been developed that can minimize the damage from a destructive earthquake if only those standards were adopted. The Alaskan pipeline that transports oil from the North Slope to the Port of Valdez is an example. Again the matter becomes an issue of implementation—understanding the hazards and risks and having the willingness to do something about it.

I was just recently involved in a study of a sector of the lifeline issue for the American Association of Engineering Societies entitled "Vulnerability of Energy Distribution Systems to an Earthquake in the Eastern United States—An Overview". I am providing you with a copy of this paper so that it can be entered into the record. This paper primarily addresses itself to the seismic vulnerability of the interstate energy distribution systems that include pipeline, electrical generation and transmission, water carrier, motor carrier and railroad. The paper reports that

if a destructive earthquake in the east were to occur, the major damage would most likely be confined to those systems in the epicentral area of the earthquake. However, it did point out that if such an earthquake occurred near the Georgia-South Carolina border severing major pipelines passing through the area, nearly six million people up the East Coast, over half being in New York State, could be without or experience shortages of natural gas. While such an event may be considered unlikely there is no scientific or engineering evidence to say it could not happen. In other words, for such events the impact could be devastating to people hundreds of miles from where the earthquake occurred.

In addition, as discussed in the paper, eighty percent of the United States population lives east of the Rocky Mountains and sixty percent lives east of the Mississippi River. To support this heavily populated area of the United States over twenty-five percent of our total energy consumption is transported by pipeline and to some extent by water up the Mississippi River from the south and southwest northward. A large portion of this energy passes through or near the New Madrid seismic zone. As has been testified to before at hearings in the House by Dr. Arch Johnston, there is a high probability of another destructive earthquake in the area before the year 2000. Therefore, it is very important that the eastern U.S. be prepared in order to mitigate such effects. This can only be done through effective research, construction, planning and public awareness. Fortunately, the Building Seismic Safety Council, supported by the Federal Emergency Management Agency, has begun to examine this issue more closely. We have all read in the newspapers recently about the Ecuadoran earthquakes, the largest being 7.3 on the Richter scale, that resulted in the destruction of 30 miles of that country's main oil pipeline, forcing Ecuador to stop payments on its $8.2 billion foreign debt. I have heard estimates of the economic impact to the country being on the order of $1 to $2 billion and estimates of four to six months to restore the pipeline back to service.

When considering the issue of adopting seismic design codes for new buildings or lifelines we must understand that, since our main goal is life safety and welfare, most of our buildings and lifelines were built in the 1930's, 40's and 50's before earthquake engineering became a state of technology. Therefore, even if we were to adopt stringent seismic design codes for buildings and lifelines today it would only apply to new facilities and such facilities would only provide life safety and welfare for a very few of our citizens. A much greater problem lies within the state of our existing facilities, the seismic response of which is even more difficult to understand. In a recent report, which I will discuss later, understanding the response of older existing buildings to earthquakes and methods for rehabilitation and retrofit to minimize loss of life was stated as highest priority. Of all existing structures, brick/masonry buildings may be the most vulnerable to damage and collapse in a major earthquake. The report goes on to say that masonry is used almost exclusively throughout the 15,000 school districts that house the United States' 40 million kindergarten through high school students. In the Memphis, Tennessee area, it is estimated that the number of deaths among school children will exceed 1,100 if a major earthquake occurred during a school day.

On the issue of our understanding of the geology and seismology with respect to the causes of earthquakes, the difference between earthquakes in the East versus the West, the actual seismic hazards that exist at a location, etc. the scientists and engineers have much to do. Currently, in many cases, especially in the East, we only have ideas with very little fact. However, this does not prevent the engineer from using a conservative approach and making decisions on what seismic hazard levels to design a critical facility for. In any engineering structure there is always that element of risk, nothing is risk free just as there is never a free lunch. Unfortunately, this continued uncertainty has resulted in many debates over the design levels of critical facilities and what is safe enough. If we as engineers are going to help improve the quality of life, then decisions must be made and facilities must be built and, we hope, with the appropriate safety measures. In any event, Mr. Chairman, the scientists, like our friend Dr. Arch Johnston and agencies like the United States Geological Survey, must continue their research. I have seen much progress in the past ten years in this area and I hope to see even more in the next ten years because if I don't, we will continue to subject the citizens of this country to higher than necessary seismic risk and we will continue to fall behind in the international race as I will discuss more fully below.

With respect to the state of science and engineering, we have had very strong programs in the past and we continue to have strong programs. However, today we have a threat of a magnitude that has not been experienced by the engineering and scientific professions of this country since World War II. This threat is the slippage of our scientific and technical leadership role in the world and it is happening in

the "earthquake industry" as well as other scientific and technical fields of endeavor. Thus, I would like to now address my remarks to this problem of our international competitiveness, focusing on the "earthquake industry", and the implications of what the current international events mean to this country in the long term.

During the 1960's and 1970's the United States' scientific and engineering professions were considered the world leaders in the "earthquake industry". When a country had a destructive earthquake that resulted in significant damage and loss of life the U.S. engineers and scientists were asked to visit the site to help with the assessment of the damage loss, to determine what could be done in the future to better understand that country's earthquake hazards and to assist in designing structures to be more resistant to earthquake forces to prevent such damage and loss of life in the future. In most all cases the U.S. engineering and scientific groups were the dominant foreign country represented, if not the only foreign country present. In a sense, we were able to reap the benefits—benefits that were vital to our earthquake scientists and engineers since the occurrence of earthquakes were our only testing laboratory. This was basically true in Turkey in 1970, 1971 and 1976; Nicaragua and Yugoslavia in 1972, Romania in 1977, Algeria in 1980, Italy in 1980 and Greece in 1981. However, in Chile in 1985, Mexico in 1985 and El Salvador in 1986 the picture began to change drastically. For example, after the September 19, 1985 earthquakes in Mexico which destroyed over 300 large engineered buildings and killed over 10,000 people in Mexico City, I am told that about thirty engineers and scientists from the United States went down to study the aftermath. However, they were joined by at least twice as many engineers and scientists from Japan. Most recently, on the first anniversary of that earthquake on September 19, 1986 the Mexico City News ran a story entitled "Proposed Building Code Could Curb Medium Rise Construction". The reporter was interviewing Dr. Roberto Meli, one of the eminent engineers in Mexico, on the new building code provisions to help prevent what happened to buildings in the 1985 earthquake. Dr. Meli was quoted as saying "Studies used in developing the new code were done in Mexico, though the group incorporated developments from other countries, especially Japan". He was further quoted as saying "The Japanese have studied this much more deeply than engineers of other countries".

In San Salvador, El Salvador the United States Office of Foreign Assistance and the Agency for International Development had bought teleseismic and strong motion instrumentation systems and had them installed in arrays by U.S.G.S. scientists. Immediately following the 1986 San Salvador earthquake, I am told that the raw data from these instruments would have gone to the Japanese if it had not been for the influence of an American engineer, Prof. Meta Sozen of the University of Illinois, visiting at the time—data that this country needs to better understand the response of structures to real earthquakes. The Japanese had previously established a good working relationship with the Salvadorians since the Salvadorians had participated in a program which brings persons from developing countries to Japan to study seismology and earthquake engineering.

The National Science Foundation has presented materials that show that both West Germany and Japan are investing almost twice the percentage of their GNP into non-defense R&D as is the United States. Thus, it was not ironic that at the Eighth World Conference on Earthquake Engineering, held in San Francisco in 1984, that the Japanese had over 300 and the West Germans 30 conference attendees—Japan having the number one foreign participation and the West Germans the number two spot. China was number three with 28 attending the conference.

Recently, Mr. Ed Keen of the Bechtel Corporation showed that out of the total Japanese engineering and construction contracts obtained outside the country of Japan, the percentage of those contracts in this country increased from three percent in 1981 to twenty-six percent in 1985—an increase by a factor of nearly ten. He also stated that one of the seven Japanese engineering and construction high technology areas where they have the leading edge over American firms in the world competition for new work is in "Seismic Building Design and Methods".

Dr. Akio Watatani of the Ohbayashi Corporation, with its U. S. headquarters in San Francisco, told a group of earthquake engineers and scientists that in fiscal year 1986 his company spent $25 million on research and had a full time staff of 187 researchers. Prof. George Housner of The California Institute of Technology and Chairman of the Committee on Earthquake Engineering told me that the Kajima Corporation, the largest construction company in Japan, has approximately 400 persons in its research laboratory.

The Chinese are not far behind the Japanese. Following the disastrous 1976 Tangshen earthquake when over 200,000 people were killed, the Chinese government began to build up a strong earthquake engineering research program. Today the In-

stitute of Engineering Mechanics in Harbin has 500 researchers and support personnel doing earthquake engineering research and at the Academy of Building Research in Beijing they have 1,200 personnel and most are also involved with earthquake research.

Dr. Tom Anderson of Fluor Corporation said last week that Fluor was now facing a greater threat from the Koreans than the Japanese in the engineering and construction business. The Koreans are making a steadfast effort to move outward in the engineering fields outside their own country. They are estimating the same number of labor hours as Fluor for engineering and construction work but with cheaper labor hours. Thus, Fluor Corporation is having to continue to provide new and unique technology that the Koreans don't have in order to try to compete. Dr. Anderson's assessment of the Koreans is that they are "quick to change" and "quick to learn".

In my opinion, the advantage that U.S. engineering and construction firms must have to compete in the future will be to maintain high quality in-house technical expertise to do research and they must maintain close relationships with the backbone of our country—our educational systems—our universities that must carry forward sound and active research. Unfortunately, our university support has been declining over the years and our engineering and construction firms do not support major in-house research programs. If this trend does not change, we will continue to slide downward like many areas of our manufacturing.

As I mentioned earlier I am Chairman of the Advisory Panel for review of the feasibility study being conducted on a National Earthquake Engineering Experimental Facility which was supported by the "Administration" (Letter of February 15, 1985 from Dr. George Keyworth, then science advisor to the President, to the Director of the Federal Emergency Management Agency). Such a facility would be of the cost and scale of the proposed Center for Neutron Research, now called the Advanced Neutron Source, for the Oak Ridge National Laboratory that you are familiar with, Mr. Chairman. As part of this study an assessment was made of the number of experimental earthquake shaking table test facilities around the world and how the United States compared. The largest table in the United States is at the University of California-Berkeley and has an area of about 37 square meters. In contrast, the two largest tables in the world have areas of 225 square meters in Japan and 900 square meters in the USSR. Other tables exist in the United States but many are outdated, inadequate, need upgrading and/or are too small. Since 1980, only one table has been constructed in the United States and there are no plans for others. In contrast, the Japanese have built 14 tables in the 1980's and Dr. Al Clark of MTS Systems Corporation, currently the world's leading supplier of shake tables, told me last week that they now have a contract with Kumagai-Gumi engineering and construction company to build another large shake table. In 1985 Kamagai-Gumi had six major projects in the United States representing over $500 million in revenue. Dr. Clark also stated that the major engineering and construction companies in Japan are strongly interested in investing capital dollars for good large scale testing facilities. Other countries, including Germany, China, the USSR, Romania, Italy, France, Yugoslavia and Greece have variously substantially increased their testing capabilities since the 1970's; even Algeria, which had no earthquake engineering capability before 1980, now has two shake tables and an Institute of Earthquake Engineering and Applied Seismology. Dr. Clark further told me that MTS Systems is now negotiating with the USSR for another table.

As a result of the completion of the first phase of the four phase study for the National Earthquake Engineering Experimental Facility the Advisory Panel has issued a report "Review of Phase I of the National Earthquake Engineering Experimental Facility Study" published by the National Academy Press and we have copies here today for your review. In this report the Advisory Panel strongly recommends that improvements of experimental facilities for earthquake engineering are urgently needed and that a broad feasibility study must be undertaken to provide an essential basis on which decisions can be made regarding construction of a National Earthquake Engineering Experimental Facility or alternatives. Unfortunately, Mr. Chairman, the Advisory Panel has been told that funds are not available to continue such a study. I submit to you, Mr. Chairman, that this lack of research and development funding is one of the root causes of this country's decline in the international marketplace. This country needs a large scale testing facility to better understand the response of full scale structures during earthquakes to minimize damage and reduce loss of life. If we were to build such a facility it would show the world that we are not only committed to saving lives around the world but that we are dedicated to remaining a world leader in this scientific and technical field.

Mr. Chairman, I submit to you that the "earthquake industry" has fallen from its world leadership position like the auto industry and the steel industry. In order for the "earthquake industry" to regain its leadership role more non-defense R&D is going to have to be fused into the overall earthquake programs. Many were pleased to see the National Science Foundation establish a National Earthquake Engineering Research Center. However, many more were disturbed that no new monies were provided to support this new initiative. Everyone is pleased that the National Science Foundation's five year plan calls for doubling the budget, but the signals some earthquake researchers are getting is that earthquake funding may decline. Even if earthquake research funding is increased, it is going to take more than that to turn our current state around. We must also realize that, while the establishment of an earthquake "center" has great potential, it will not alone solve the difficult and intricate problems toward the advancement of the "earthquake industry". We must continue to support and depend on our traditional research activities. It has been some years since the United States has experienced a severely destructive earthquake and a feeling seems to be developing that it is now all right to cut back on earthquake engineering research. In my opinion this slacking off will only lead to a large increase in funding following the next destructive earthquake and it is well known that such a large oscillation in research support is not a cost effective method of solving a problem.

One area that also needs to be addressed is further research and development support that results in the form of aid to Third World countries—countries where devastating earthquakes occur quite frequently. One very positive way to do this is through the "International Decade of Hazard Reduction" (IDHR) proposed by Dr. Frank Press, President of the National Academy of Science, at the Eighth World Conference on Earthquake Engineering. The United States must take a leadership role in this activity to show the world that we are interested in saving lives and helping other countries to mitigate the damage resulting from devastating earthquakes and other natural hazards. In addition, by maintaining a leadership role in IDHR will allow for ready access of our scientists and engineers to study the effects of an earthquake and how structures respond to earthquakes—our only real full scale testing laboratory. If this country will strongly support the IDHR, the payback in the long term can be significant. We may not see the payback immediately but we should see it when the next devastating earthquake hits this country.

By allowing for the further study of actual earthquakes and earthquake damage, the IDHR program will also allow the engineers and scientists to become better at "loss estimation studies", an area badly needing improvement, especially for the insurance industry. The Academies have been studying this problem of loss estimation and a report is forthcoming. I was told at the recent Second International Earthquake Conference on April 6-10, 1987 in Los Angeles, California that the Director of the Seismological Bureau of China, Dr. An, invited total exchange with the City of Los Angeles and the State of California because they need our assistance. We must nurture that request and what better way than through the IDHR. The IDHR is a must to the "earthquake industry" if we are going to maintain our leadership role in the world and most importantly, learn to better understand the earthquake phenomena in order to protect life and property in this country.

In summary, Mr. Chairman, the United States is as vulnerable to a destructive earthquake in the near future as any of the other countries I have mentioned in my testimony today. Around the world over 40 countries have had destructive earthquakes in recent history and it is only a matter of time before the next one occurs in the United States. As I have pointed out, with its heavy population, concentration of energy distribution systems, lack of frequent earthquakes as a reminder, and relative seismic quiescence in the 20th century the eastern United States is a sleeping giant to be awakened by the unexpected. Regardless of where the future earthquakes of this country occur, it is imperative that as a country we be prepared. We must begin to act now if we are to save lives from future events and mitigate the resulting damage.

We cannot afford the luxury of sitting by and waiting for a "direct hit" from even an earthquake of moderate magnitude like the October 10, 1986 5.4 magnitude San Salvador earthquake that produced earthquake forces most often associated with earthquakes of magnitude 6.5 or higher. However, it is my opinion, and I know others that share it with me, that unless extraordinary effort is put forth in the next decade in mitigation, research and development our citizens will continue to be like "sitting ducks". For sure, Japan, China, Algeria and others are taking action. Action, in many cases, that has been so effective internationally that I have devoted a major portion of my testimony to the international picture.

At home, we must continue to support the preparedness projects; the Central United States Earthquake Consortium (CUSEC), the Southern California Earthquake Preparedness Project (SCEPP), and others so that our disaster preparedness activities are strengthened. We must upgrade our existing testing facilities and we must be bold about the development of new large scale testing facilities. We need to develop better methods of assessing earthquake hazards, we need to know how to engineer structures for controlled damage and we must develop better methods for strengthening old, hazardous buildings, especially our school buildings and we must push forward in the many avenues of research and development. An increase in non-defense research and development funding must occur in science and engineering and the "earthquake industry" must experience its fair share of these increases if something is to be done.

There are no real reasons why we cannot have a building code for the East that addresses the earthquake problem to its fullest, there is no reason why we cannot be prepared for that inevitable event and there is no reason why we cannot still be Number One in the world of scientific and technical leadership. We are not only in a natural hazards race with Mother Nature, but we are in an economic hazards race with other countries of the world and we cannot afford to lose either one. Following Dr. Frank Press' challenge for an International Decade of Hazards Reduction at the Eighth World Conference on Earthquake Engineering in 1984, Mr. Chairman, in the next decade of the National Earthquake Hazards Reduction Program, I would challenge this country and its engineering and scientific professions to a National Decade of Preparedness, Technological Assessment and Development. Thank you.

Senator GORE. Thank you very much. We certainly appreciate that statement.

Our final witness will be Mr. L. Thomas Tobin, Executive Director of the California Seismic Safety Commission based in Sacramento.

Welcome, Mr. Tobin.

STATEMENT OF L. THOMAS TOBIN, EXECUTIVE DIRECTOR, CALIFORNIA SEISMIC SAFETY COMMISSION; ACCOMPANIED BY DR. WILFERD D. IWAN, CHAIRMAN

Mr. TOBIN. Thank you, Chairman Gore. Thank you for the opportunity to testify on behalf of the California Seismic Safety Commission.

Before I start, I would like to introduce Dr. Wilferd Iwan, who is Chairman of the Commission and a Professor at the California Institute of Technology. Dr. Iwan is sitting behind me at this time.

I would also like to request that my written testimony be entered into the record of your hearing.

Senator GORE. Without objection.

Mr. TOBIN. The Seismic Safety Commission was created in 1975 to provide a focal point for California earthquake policy. Its most important responsibility is to ensure that earthquake safety, hazard mitigation, emergency planning and response, and recovery are given proper attention and not lost among multiple priorities, conflicting issues and funding constraints that affect our State.

The Commission is also responsibility for annually revising a five-year earthquake hazard reduction program. We believe our experience gives us some insight into the national program.

Although the national earthquake hazard reduction program has been successful in California, and California has a well developed earthquake hazard reduction program of its own, much remains to be done to protect life and property.

We urge you to reauthorize the act, and to consider amendments to strengthen the program.

In this testimony, we wish to comment on the budget, program leadership, and priorities.

The Federal program has been underfunded since its inception, and the situation is getting worse. The program was funded in 1977 at a bare minimum amount, and since then, funding has remained essentially level even though the demand for assistance has increased dramatically across the nation, and even though inflation has chopped the real dollar value in half since the program began.

The shortfall means critical research is not being done; that programs to assist state and local governments are outrageously underfunded; and the nation's progress in earthquake hazard reduction suffers.

The fiscal year 1988 budget will cause cuts in studies regarding the buildup of strain across California's faults; it will mean fewer dollars to help local governments and private businesses apply what we already know; it will mean some of our researchers and laboratories will not be able to carry out vital studies on hazardous buildings; and it will mean that more people will die than need to.

At this point I would like to echo testimony by Dr. Johnston and Dr. Beavers regarding the decline in earthquake research. In California, we have state-of-the-art test facilities going unused for lack of research money. We have earthquake researchers who, for lack of research money, are turning to defense research on missile silos and blast detection. The number of graduate students in some earthquake engineering programs has declined to one-third or one-half the number just three years ago.

Our research efforts in California are crumbling just at the time when the state law requires identification of hazardous buildings; at a time when governments and businesses are willing to bite the bullet and strengthen unsafe buildings; at a time when ten years of research and investment in test facilities has set the stage to attack our biggest problem, existing hazardous buildings.

We may well need new programs and facilities, but you cannot abandon the researchers and the research facilities that have already been established, and are intended to produce the results that we need.

The fiscal year 1988 budget request for $67 million, amounts to only 25 cents per American, half the cost of a pack of chewing gum. The Federal Government's interest in California, in defense installations, alone justifies spending more on the program. When you also consider the huge cost of disaster aid to rebuild the economy and to rebuild buildings, a stronger program is obviously needed. More importantly, much of what we will lose in earthquakes can be prevented. Simply put, we can pay some now, or a lot more later in dollars and lives.

You should also consider the question of leadership. Leaders determine how aggressive a program will be; what it will emphasize; whether budgets will be increased or cut; what efforts are high priority; and whether the program will progress in a coordinated, effective manner.

The Federal program needs stronger leadership. At present, the program is fragmented. Except for the reauthorization process, there is no one place where the program is viewed as a whole.

We strongly recommend that the budget should be viewed as one item, as a line item, in the President's budget.

Since earthquake programs make up but a small fraction of each agency's budget, high level management support is lacking. Nationwide leadership is also missing.

Who speaks at the national level on earthquakes? And did you hear from any of the four principal agencies regarding the critical role housing programs can play to reduce hazards when you considered the recent legislation? If I were you, I would wonder why not.

The 1980 amendments to the Act made FEMA the lead agency. They only empowered FEMA to set goals and priorities, not to see that the other agencies carry them out.

That situation is similar to ours in California, where 25 agencies each has a small piece of the program. A commission allows us to bring together representatives of each level of government with representatives of several disciplines and interests.

We recommend creating a permanent, independent commission to provide visible leadership, and to guide the national earthquake hazard reduction program. But if this recommendation is too radical a structural change in Federal Government, we would strongly then recommend that you mandate a permanent independent advisory committee that has an actual role in the running of the program. Earthquake hazard reduction is far too important to have a leaderless program lost among competing demands and priorities in the crush of everyday business in Washington, D.C.

Program priorities are also important to consider at this time. We will accomplish the goals of the Act if we focus our nationwide efforts on two main objectives: first, reduce existing hazards; and second, prepare plans and develop the capability for emergency response to region-wide disasters.

Direct research to these objectives: assist state and local governments to deal with these objectives; direct all Federal agencies to use their other programs to address these objectives; see that Federal agencies forge incentive programs to encourage local governments and private owners to address these objectives.

Seismic safety policies and practices in California have incorporated research to an unparalleled extent. Our building codes are constantly being revised. We have passed over 30 seismic safety laws in 10 years. We have initiated planning efforts with local governments to respond to a possible prediction. Rather that resisting new information, we demand it. So while research results are quickly used to save lives, and our preparedness projects, BAREP and SCEPP, which have been mentioned earlier, are wildly successful at transferring the latest information into concrete action, much more needs to be done at the local level to reduce hazards. Just as earthquake research is carried out by the USGS and NSF is underfunded, so are the programs to help local governments use what we already know.

We can't count on earthquake insurance. At present, it neither serves the interests of the insured nor the insurance companies. There is neither a viable source of significant recovery funds, nor is it an incentive to reduce hazards. Earthquake insurance needs to be reviewed at the Federal level.

While we are proud of our many accomplisments at the state and local levels of government, and we are proud of the exciting programs carried out by the private sector in California, only a handful of our 485 cities and counties, and thousands of businesses, have been reached. Assistance programs, and programs to transfer existing knowledge and technology must be given equal priority to efforts to extend our knowledge.

Recognize that ultimately local governments and the private sector are responsible. And unless you commit to and fund a long term effort, that program will never reach the critical mass where a majority of cities and counties and businesses are addressing earthquake hazard reduction. When we reach that point, however, the earthquake hazard reduction program will become part of our lives, and the national program will be a success.

Mr. Chairman, California has adopted a goal by legislation, and that is to reduce statewide earthquake hazards significantly by the end of the century.

We call on you to share our goal. Make New Year's Day, of the year 2000, the date to achieve significant hazard reduction nationwide.

Mr. Chairman, I would like to invite you and Members of the committee to California to view our progress.

I would be pleased to answer questions later, and I would like to remind you that Dr. Iwan is also with me to answer questions.

Thank you very much for hearing us.

[The statement follows:]

STATEMENT OF L. THOMAS TOBIN, EXECUTIVE DIRECTOR, CALIFORNIA SEISMIC SAFETY COMMISSION

INTRODUCTION

This statement is offered on behalf of the California Seismic Safety Commission in support of reauthorizing the National Earthquake Hazards Reduction Act (NEHRA). This statement will describe the importance of NEHRA to, and some of its accomplishments in, California; describe California's earthquake hazard reduction programs; and recommend actions to strengthen the federal program.

The Seismic Safety Commission is an independent state commission established in 1975 to advise the Governor, Legislature, state and local agencies, and the private sector on earthquake safety policy.[1] It is an independent agency composed of 17 commissioners chosen for their expertise and experience. Fifteen of the commissioners are appointed by the Governor upon consent of the Senate, one commissioner is from the Senate, and one is from the Assembly. The Commission investigates earthquakes, studies earthquake-related issues, and recommends to the Governor and Legislature policies and programs needed to reduce earthquake hazards. A further listing of the Commission's responsibilities is provided in Figure 1.

Although the Commission has a number of responsibilities, its most important role is to serve as a "policy watchdog," charged with ensuring that earthquake safety, hazard mitigation, emergency planning and response, and recovery are given proper attention and are not lost among the issues and funding constraints that affect the state.

The Commission and many of its members have worked to establish the National Earthquake Hazards Reduction Act. Present and former commissioners were and continue to be active on expert review panels such as those that led to the National Earthquake Hazards Reduction Program's (NEHRP's) five-year plan and the current review of the plan. California will continue to develop new and more effective ways to reduce earthquake hazards, and share its experience and expertise in a cooperative manner with the federal program.

At present, the Commission has a cooperative agreement with the Federal Emergency Management Agency for the Bay Area Regional Earthquake Preparedness Project. Half of the project's $750,000 budget is provided by the Commission with state General Fund money and half by FEMA funds appropriated under the National Earthquake Hazards Reduction Program. Since 1977 the Commission has administered $4,778,350 NEHRA funds.

The Commission is thoroughly familiar with the federal program and, perhaps, is in a unique position to offer advice. It is in light of its responsibilities, and its direct experience in earthquake hazard reduction programs, that the Commission presents its testimony.

CALIFORNIA SEISMIC SAFETY COMMISSION

RESPONSIBILITIES

- Recommending to the Governor and Legislature policies and programs needed to reduce earthquake hazards;
- Reviewing earthquake-related activities funded by the state;
- Providing consistent policy direction for earthquake-related programs for agencies at all government levels;
- Proposing and reviewing earthquake-related legislation;
- Conducting public hearings on earthquake safety issues;
- Requesting state agencies to devise, modify, or incorporate criteria and standards that promote earthquake safety;
- Conducting investigations following damaging earthquakes on damage, recovery, and reconstruction efforts;
- Gathering, analyzing, and disseminating seismic safety information, stimulating research, and encouraging training;
- Preparing and revising a five-year action program to reduce earthquake hazards statewide significantly by the end of the century;
- Assisting local governments to identify the most seismically hazardous buildings in California and develop plans to mitigate their hazards;
- Administering the California Earthquake Education Project curriculum for use by public and private schools to help teach science and earthquake preparedness in grades four through eight; and
- Establishing the Southern California Earthquake Preparedness Project (SCEPP) in 1981 and the Bay Area Regional Earthquake Preparedness Project (BAREPP) in 1984.

FIGURE 1. California Seismic Safety Commission Responsibilities

THE THREAT IN CALIFORNIA

Scientists agree that a major earthquake can strike California at any time. The odds are 50-50 that a major earthquake will strike a California metropolitan area within the next twenty to thirty years.[2] Moreover, Californians must also be concerned about damaging moderate earthquakes, which will continue to strike much more frequently than the major quakes. For example, the 1971 earthquake at Sylmar, only a magnitude 6.6, caused over $2.6 billion in damages and took 64 lives. The 1983 magnitude 6.7 Coalinga earthquake caused $7.5 million in damage. During the last 140 years, more than 83 earthquakes over magnitude 6 have shaken California. (Figure 2 illustrates the location of major faults and significant earthquakes.) California has responded by developing an active hazard reduction program that will be explained in more detail later in this testimony and in Appendies A and B.

When a major event – that is, over magnitude 7 – strikes a metropolitan area, the damage will be widespread. Forecasts indicate that thousands of lives may be lost, that tens of thousands may require hospitalization, and that hundreds of thousands will be left injured and homeless. Estimates of direct physical damage from shaking go as high as $50 to $70 *billion.*[3] Fire could add $17 billion more to these losses.[4] Unless we substantially step up our hazard reduction programs, and fate allows us ten to fifteen years to carry them out, the next California earthquake will be a catastrophe with national consequences. And the federal government has an interest in California earthquakes far beyond its legitimate concern for the welfare of Californians.

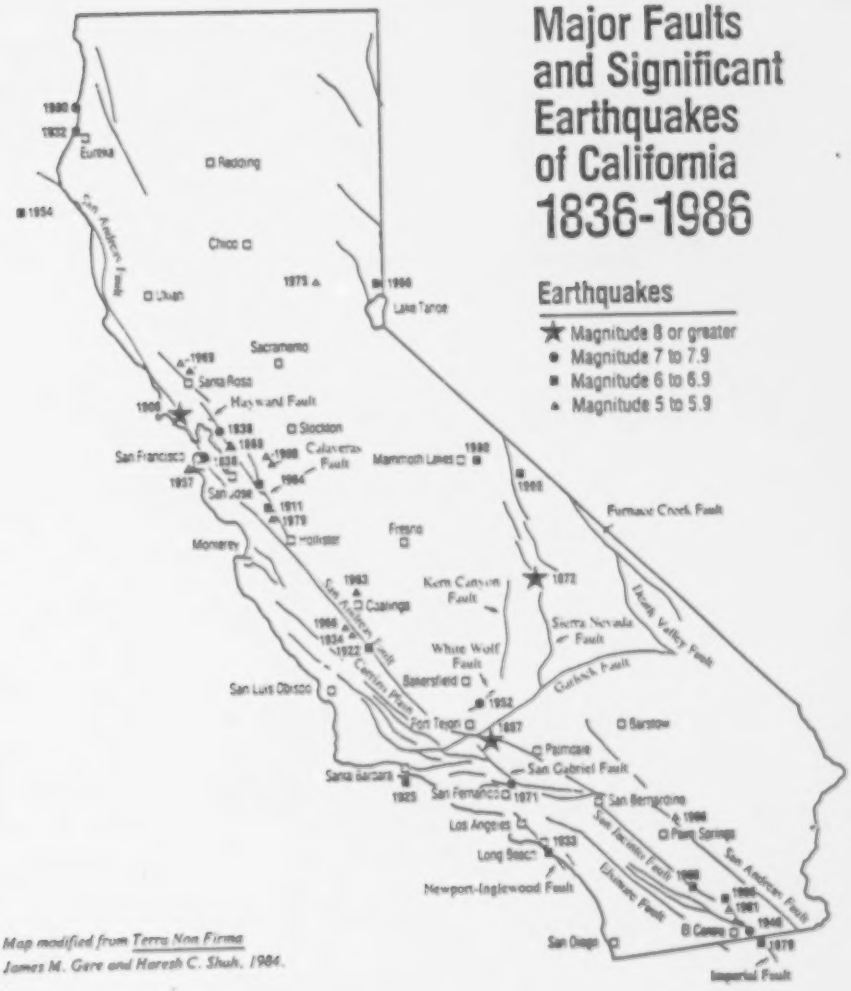

Figure 2. Major Faults and Significant Earthquakes

THE FEDERAL STAKE IN CALIFORNIA

The federal government obviously has a large presence in California, but the importance of its earthquake programs to the nation may not be as clear. Earthquake hazard reduction programs are of direct interest to federal activities. In the aftermath of a large earthquake in California, the federal government will be forced to respond with billions of dollars in aid to help rebuild the infrastructure and economic base. Federal facilities and contractors will be damaged. A brief review of California's contribution to the nation's defense illustrates the point.

The Department of Defense alone employs over 340,000 military and civilian persons at dozens of bases and installations in California. Major defense and space contractors in California include Rockwell International, Hughes Aircraft, Lockheed, General Dynamics, McDonnell-Douglas, Summa, Northrup, and TRW. (Figure 3 illustrates the location of key military bases and defense contractors.) California businesses carry out over 14 percent of the federal government's nondefense contracts; California firms have been awarded from 15 to 20 percent of all prime defense contracts since 1963; and in 1984, 52.5 percent of weapons procurement, 38.6 percent of missile and space equipment, and 25 percent of aircraft orders were filled in California.[5]

California also plays an important role in the economy of the nation and of Pacific Rim countries. Annual exports to Pacific Rim countries exceeds $65 billion. Banking interests estimate that loss of one major bank's data processing capability will have crippling effects on this activity. If the loss lasts three days the California economy will be impacted; if the loss lasts five days, the nation's economy will be impacted; and if the loss lasts seven days, the world economy will be impacted. If several banks in a region loose data processing capability, the impact on the economy will be devasting.[6] These far-reaching effects are caused by the volume of financial transactions that take place in the Los Angeles and San Francisco regions.

It is clear that the federal government's exposure to earthquake risks in California and in the other seismically active states is great, yet the federal government's support of earthquake safety programs is comparatively small. The FY 88 funding level of $67,078,000 represents about 25 cents per American - the cost of one game at a video arcade. The federal budget appropriates less than one of every $15,000 dollars in the federal budget for earthquake hazard reduction even though so many lives, so much activity, and the nation's defense capability are at stake.

Figure 3. Defense Map of California (Golden State Report, July 1986)

PROGRESS IN HAZARD REDUCTION

Progress has been made, albeit slowly, in spite of inadequate funding of NEHRP. Awareness of the earthquake threat, and of mitigation measures, has improved. A public opinion poll conducted on December 17, 1985 by Mervin Field indicated that 89 percent of Californians are aware that their area is likely to be damaged by an earthquake. This statistic represents an increase of 16 percent above the 1979 awareness level. But awareness is not enough. The same poll also revealed that an equal number, 89 percent, were not worried. There is a crucial gap between being aware and taking action, between having good intentions and actually reducing hazards at home and in the workplace.

State and local government and private sector programs have also grown. The level of planning and preparation in public and private schools has increased dramatically. All of these improvements since NEHRA was passed are due to cooperative efforts of the NEHRP agencies - FEMA, USGS, NSF and NBS - and the State of California. Although it may not be possible in this testimony to detail precise cause-and-effect linkages between the federal, state, local government, and private sector programs, it is clear that our progress to date has been helped and supported by NEHRP. A brief summary of progress in earthquake hazards reduction since passage of NEHRA will better illustrate the point that federal dollars spent in California will save lives because the laws, organization, and wherewithal to accommodate information provided by NEHRP is in place.

State Government Accomplishments

California is the state most at risk from earthquake hazards, and it has responded with the most comprehensive state earthquake program in the nation. State-funded programs have been strengthened to address life-threatening hazards and improve emergency response. Since 1977, state funding for these programs has grown by 56 percent, from $16 million to $25 million during FY 85/86.

Figure 4 illustrates the state agencies and expenditures for earthquake safety programs; a more detailed summary of key state programs which illustrate the scope of our existing effort, is in Appendix A.

Since 1977 the state has enacted over thirty new laws creating a number of new activities and committing new funds. Figure 5 summarizes recent legislation. No other state that has mounted a similar effort, and there is no other state where so much more is needed.

SUMMARY OF ESTIMATED 1985-86 STATE GOVERNMENT
EXPENDITURES FOR EARTHQUAKE HAZARD REDUCTION ACTIVITIES

AGENCY	ACTIVITY	1985-86 Expenditures ($)
Department of Conservation—Division of Mines and Geology		
	• Basic Investigations	466,000
	• Geological Information	550,000
	• Hazards Reduction	1,768,000
Office of Emergency Services		
	• Earthquake Prediction Response	3,072
	• Earthquake Response Planning	1,035,000
	• Public Information on Earthquake Safety	69,968
California Energy Commission		
	• Energy Commission Power Plant Certification	425,000
Department of General Services, Office of the State architect		
	• Essential Services Buildings	95,000
	• Structural Safety of Hospitals	(4,771,000)
	• Structural Safety of Schools	3,651,000
Office of Statewide Health Planning and Development		
	• Building Safety Board	8,000
	• Hospital Construction Review	12,899,000
Department of Insurance		
	• Probable Maximum Loss	31,196
Public Utilities Commission		
	• Bay Area Rapid Transit Earthquake Preparedness Plan	6,000
	• Utilities Earthquake Preparedness Plan	19,000
Bay Conservation and Development Commission		
	• Engineering Criteria Review Board	10,000
Seismic Safety Commission		
	• Bay Area Regional Earthquake Preparedness Project	375,000
	• California Earthquake Education Project	175,000
	• Activities	596,000
Department of Transportation		
	• Bridge Retrofit Program	602,140
Department of Water Resources		
	• Operations and Maintenance of Seismic Instruments	487,000
	• State Water Project	410,000
	• Safety of Dams	340,000
University of California		
	• Seismographic Station	100,000
	• Earthquake Engineering Center	500,000
TOTAL		$ 24,916,256

Figure 4. Summary of California State Expenditures

SEISMIC SAFETY LEGISLATION IN CALIFORNIA: 1979 TO 1987

1979-1980

- Authorized the Seismic Safety Commission to issue subpoenas.
- Permitted local jurisdictions to lower building standards for the rehabilitation of pre-1933 buildings.
- Required the Seismic Safety Commission to do a study on Earthquake Hazard Reduction and Prediction.
- Established the Southern California Earthquake Preparedness Project.

1981-1982

- Required mobile home seismic bracing devices to be state certified safe before sale.
- Created the California Earthquake Education Project.
- Authorized cities and counties to sell limited obligation bonds for the purpose of rehabilitating pre-1933 buildings.

1983-1984

- Required essential services buildings be designed and built to resist earthquake forces.
- Required schools to establish earthquake emergency procedures.
- Created the Bay Area Regional Earthquake Preparedness Project.
- Required the Seismic Safety Commission to study the Coalinga earthquake.

1985-1986

- Required most cities and counties to inventory pre-building code buildings and to draft a mitigation program by 1990.
- Established a California Center for Earthquake Engineering.
- Extended the Southern California Earthquake Preparedness Project and the Bay Area Regional Earthquake Project to 1990.
- Established a study for an earthquake early warning system.
- Required the state to develop with the federal government an earthquake prediction system on the San Andreas fault.
- Created the Earthquake Emergency Investigations Account for purposes of post-earthquake investigations by state agencies.
- Requires careful checking of private school plans and construction.

Figure 5. Recent Seismic Safety Legislation Enacted in California

Local Government Accomplishments

It is difficult to summarize the earthquake hazard reduction efforts underway in each of the state's cities and counties. The local level of government is the one most directly concerned with earthquake safety, since it has primary responsibility. In California, local governments are responsible for building code enforcement, land use planning, emergency response, housing programs, redevelopment, and much of the recovery effort.

While a number of outstanding local government programs (described in Appendix C) have been initiated to identify and strengthen hazardous buildings, to reduce risks to government facilities and operations, to plan for responding to a prediction and to a disaster, and to prepare for recovery. Unfortunately, only a tiny minority of California's five hundred local jurisdictions as yet have such programs.

Because of the magnitude of the earthquake threat, local government must look to the state and federal governments for leadership, incentives, and financial resources. The federal program must be adapted so that it better responds to this situation.

Private Sector Accomplishments

It simply makes good sense for businesses to manage risk, and earthquake risks can be dealt with as any other risk. Insurance industry statistics indicate nearly two-thirds of all businesses fail following a disaster for which they were not prepared. In short, corporate officers have a fiduciary responsibility to protect corporate assets by preparing for an earthquake.

Seismic safety efforts carried out by private businesses are difficult to summarize. Though there has been a general lack of preparedness planning by the majority of firms, great progress has been made by some businesses, as described in Appendix D.

It is clear that industry is doing things never heard of just ten years ago, but many more such programs are needed. They will happen only if the federal government demonstrates that it takes earthquakes seriously and is willing to encourage work with the private sector to reduce hazards and develop emergency response capability.

Implementation of NEHRA in California

The NEHRP and predecessor programs have provided California with invaluable assistance in seismic safety activities. Government policies in California at the state and local levels have reacted to research and discoveries sponsored or performed by NEHRP organizations.

- Prediction effort has resulted in state laws regarding a prediction evaluation system, protection from liability for government officials acting on a prediction, and preparation of a

state prediction response plan. Several local governments are preparing prediction response plans.

- The Southern California study[7] is a landmark compendium of valuable and useable earth science information. Similar efforts are needed to make new information available quickly.

- New standards for the design of highway structures and techniques to strengthen existing structures were developed from research sponsored by NSF and NBS. The latest revisions in the seismic building code used in all of the western states built upon the work behind the "NEHRP Provisions,"[8] and the report serves as a valuable commentary.

- The California Strong Motion Instrumentation Program, consisting of over four hundred installed recording devices, is made more effective by sharing the distribution of stations in a complementary fashion.

- A network of 600 sensitive seismographs allow accurate recording and location of earthquake and delination of active faults. State and local government officials and the news media rely on USGS scientists to interpret the meaning of increased seismic activity. State law and local land use policies now incorporate special standards for active faults and areas prone to ground failure and landsliding.

- Emergency planning and awareness efforts have been helped by the concern for earthquakes. FEMA has supported seminars and workshops that have drawn thousands of local and state government officials, engineers, geologists, hospital administrators, and so on. The BAREPP and SCEPP projects have stimulated a broad range of activities in their areas.

- Emergency planning in public and private schools has been helped by distribution of a FEMA-prepared guidebook to schools thoughout California.

- The program has helped develop a cadre of dedicated federal, state, and local government employees and private contractors which now provides a reliable source of expert advice, and an unrelenting lobby throughout the state for hazard reduction efforts.

Federal Leadership Needed

As valuable as these state and local government, private sector, and NEHRP accomplishments are, they are merely a start. There are a few jurisdictions with exemplary programs - and the hundreds with none. Many people know about earthquakes - but few have taken action to reduce earthquake hazards. Hundreds of thousands of businesses have not addressed earthquake risk.

NEHRP and the California programs have yet to reach a "critical mass" where a *majority* of local governments, businesses, and individuals undertake hazard reduction measures and sustain the

effort as a permanent way of life. If government leadership and programs were eliminated, the effort would cease, and in a few years all our progress to date would be lost.

Now, when there is great receptiveness to hazard programs, is the time for the federal program to strengthen its hazard reduction efforts in conjunction with states and local governments. The federal government must provide leadership, money, and technical assistance to local governments. The federal program must accommodate this situation by providing increased assistance to local government programs.

In California, increased federal funding will save lives, protect the federal interests, and the economy. New information on fault locations, earthquake recurrance intervals and magnitudes, location of hazardous soil conditions, soil response, and engineering research on response of existing structures, techniques to strengthen such structures, and ground motion will quickly be used to reduce hazards.

California's Priorities and Programs

In 1985 Governor Deukmejian signed the California Earthquake Hazards Reduction Act of 1986, which established the goal of significantly reducing California's earthquake hazards by the end of the century. The initial five-year program has been prepared under the new law and published as *California at Risk: Reducing Earthquake Hazards 1987 - 1992.*[9] The five-year program provides California agencies with responsibilities for earthquake safety with a common foundation, and assures that their efforts are coordinated towards achieving the goal. Congress should amend NEHRA to set a similar goal to reduce nationwide earthquake hazards significantly by the end of the century.

California's five-year program is intended to:

- Establish priorities
- Provide common earthquake-safety objectives for all agencies and private companies
- Coordinate the work of responsible organizations
- Monitor progress in a systematic way
- Assure accountability in meeting objectives

The program also recognizes that a great deal still needs to be done, despite *ad hoc* efforts made over a sixty-year period to improve earthquake safety. The most important, but also the most costly and controversial earthquake problem is the hazard of existing unsafe structures. Although, as noted above, the state and a few local governments have recently taken some significant steps to address this problem, much remains to be done.

The program provides for a series of new initiatives to promote life safety. Its priorities stress initiatives dealing with existing development and emergency planning and response. New initiatives, intended to add to the existing statewide program, address existing and new development, emergency planning and response, postdisaster recovery, public information and education, and research. (A full description of new initiatives to be carried out during the current year are summarized in Appendix B.)

Although California has an outstanding record of accomplishment with coordinated multiagency earthquake safety programs, much remains to be done through federal-state cooperation in California. Reauthorization of NEHRA, providing adequate funds, and focusing on existing hazards and emergency response are of critical interest to California.

IMPORTANT ISSUES FACING THE NEHRA

Although the NEHRA has accomplished a great deal, there are certain shortcomings that should be addressed with the goal of improving the effectiveness of the act. If the federal government is truly interested in a national earthquake hazard reduction program, is it willing to commit the resources, and strengthen the leadership to make the program work in a focused, mission-oriented way? The committment of $67 million is not a strong statement of support.

Federal Leadership

Leadership has been an issue since the inception of the program. The 1980 amendments to the act did not empower the lead agency to set goals and priorities, or to see that they were being carried out. Furthermore, appropriations have never provided the resources needed for effective leadership. An original proposal was to establish an independent office to be responsible for the national earthquake hazards reduction program, and to establish an independent and permanent lead agency advisory committee.

At present NEHRP is fragmented, frustrating attempts to focus on specific goals and priorities, and implement the act's goal of a coordinated hazard reduction effort. The reauthorization process is the only meaningful opportunity for an overall look at the program.

A few examples of the fragmentation will serve to highlight the problem. The budget process is divided among four agencies, four different budget examiners at the Office of Management and Budget, three subcommittees of the House Appropriations Committee, and three subcommittees of the Senate Appropriations Committee. There is no single line item in the President's budget for earthquake hazard reduction programs even though there is statutory authority for the program. The NEHRP five-year plan should be a guiding document, and each agency's budget should be in step with it, but they are not. The committee should consider amendments to assure that the earthquake hazard reduction program and its component parts are managed in an integrated manner.

The act provides broad multiple goals, all of which are important elements of a comprehensive earthquake hazard reduction program. The existence of a number of goals, tight fiscal constraints, and no strong centralized mechanism to guide and coordinate agency efforts and expenditures results in the resources being spread too thin. The lead agency must be given the authority to set specific measureable goals for the program, establish priorities for these goals, and assure that they are met.

At present there is no provision for meaningful accountability to the lead agency. Without an enforceable mechanism to carry out priorities, participating agencies need not follow. As a result, multiple approaches to the same problem, imbalances between user needs and federal services and products, competition, and lack of cooperation can make the program less effective. The act should be

amended to provide for strong leadership and accountability. For example, accountability could require each agency to report annually to the lead agency its expenditures, along with an explanation of how the program meets the objectives set by the five-year plan. Program elements that fail to meet the plan goals and priorities would not be funded through the program.

Although the act presents NEHRP as a high priority program, its component parts are merely secondary elements of other programs. Appropriations for the earthquake programs are only small parts of each agency's budget. For example, FEMA's $5.313 million appropriation request is but 2.5 percent of the overall FEMA budget; the USGS appropriation request of $32.5 million is less than 10 percent of the USGS budget; the $0.5 million request is but a fraction of the NBS budget, and the $26.7 request is less than 2 percent of NSF's budget. In this situation one of two management attitudes may be present: The program may be regarded as an unimportant appendage to an agency's overall mission; or the agency may recognize the importance of the program to the nation, give it high priority, and whenever possible manage the other agency programs in a supportive manner. Unfortunately, an April 1986 list of FEMA priorities indicates that the earthquake hazards reduction program falls twelfth in a list of twenty of the agency's internal priorities. A similar situation may well exist at the other agencies, since the highest level government leaders show little public support. The Surgeon General's stance on smoking is well known, but where, or who, is his counterpart on earthquakes?

This situation is unacceptable. The earthquake hazard is so important that the director of each agency should give it high priority, and lend personal support and prestige to the program.

Earthquake programs and hazard-reduction priorities are too important to California and the nation to risk being lost among other competing demands and priorities. Although funds needed for lead agency responsibilities are small, and will remain so even at appropriate levels of funding, such an organization is essential to assure that the program is given strong, consistent support at the highest levels. A lead agency with this commitment must be found.

The situation in earthquake hazard reduction at the federal level is similar to that in California. Important earthquake programs constitute but a small portion of the overall responsibilities of departments responsible for emergency response, geological hazards, and structural engineering. The state responded by establishing a Seismic Safety Commission as an independent and single-minded body charged with making certain that earthquake safety is never overlooked.

A similar independent, permanent federal commission should be established to guide NEHRP. It should be given the authority, personnel, and financial resources to set goals and priorities, and see that they are being met, provide coordination, and assure that a consistent, focused national program is followed. The panel would be composed of state and local government and private sector professionals and other nonfederal government experts involved in reducing earthquake hazards. This body would be a mechanism to

provide overall direction, stature, and visibility to the program. A panel of this description could be independent of the other agencies, freeing them to conscentrate on carrying out their missions. The Office of Science and Technology Policy may be a candidate to establish such an organization.

Funding

The name of the act clearly spells out its intention: Earthquake hazard reduction. The Congress should take careful stock to see if this is occurring, and to decide what is needed to accomplish what the federal government began to do ten years ago. Hazard mitigation is primarily the responsibility of the private sector, and local and state governments, yet federal assistance to state and local governments to carry out politically sensitive and expensive hazard reduction programs, many of which must deal with retroactive building standards, is limited to two percent of the NEHRP program. Ironically, some of the program's greatest successes have come from helping the State of California nurture local government and private sector programs, yet federal funding for these programs remains inadequate, and in California it is decreasing.

The overall program is underfunded. The program is currently unable to support the level of activity needed in California. In fact, the program has never been funded at the level believed necessary in the eyes of national experts. The Newmark-Stever Report[10] made recommendations for research funding in earthquake engineering and seismology. These recommendations and the recommendations put forth by the Steinbrugge committee's[11] review of the federal 1983 five-year plan have never been met. Not only has funding for NEHRP been set at bare minimum levels, but the funding has remained essentially level for ten years while inflation has reduced its effectiveness by about one half. The gap between what the nation needs and what it gets continues to widen.

Federal earthquake hazard reduction programs in California are decreasing due to increased costs and shrinking budgets. Furthermore, recognizing that other states also have earthquake risks, federal agencies are spending their dollars increasingly on efforts to assist these states. Californians welcome efforts by other states to reduce earthquake hazards and to increase their emergency response capability and readiness, but are gravely concerned that the federal program is no longer able to meet the critical needs of the most seismically active states. Increased funding is necessary if the federal government is going to continue to contribute to reducing hazards in the states with the most at stake for the nation and the greatest proven ability to apply the results of the program.

Taking advantage of the momentum in California will require persistent efforts, a consistent program and more federal funding, not less. Faced with a reduction in funding, state and local preparedness planning, multihazard planning, research, and earthquake education and information transfer in California are not progressing as they could. The resistance to needed new programs

at the state and local government levels in California is more financial than philosophical.

In spite of the limits placed on the federal budget, Congress should immediately restore funding to its before inflation 1977 level for the next fiscal year, and provide additional funding for increased application and the new leadership activities called for above. Because NEHRP funds are already spread too thin, new responsibilities called for in the amendments must be fully funded so that they do not detract from other necessary activities. Funding to FEMA for local and state government assistance should be increased threefold Funding for subsequent years should be determined by the new five-year plan and a careful review of the landmark Newmark-Stever and Steinbrugge reports mentioned above.

Federal Facilities, Operations, and Contracting

The lead agency must be given the legal and bureaucratic tools to see that each federal agencies carries out earthquake safety programs for their own factilities and operations, and through the programs they administer, according to common priorities. The federal government is the largest employer in the nation and, as pointed out earlier, its presence in California is substantial. The federal government has responsibilities for protecting its own employees, facilities and operations, for recovery, for emergency response planning, and for research.

NEHRP could make an important contribution to national earthquake hazard reduction, and to earthquake safety in California, by adopting a program to strengthen those federally owned or operated facilities determined to be potentially hazardous. Emergency earthquake plans should be prepared for each federal facility in seismically active states. Federal employees should be trained to prepare for an earthquake at work and at home; when employees and their families are prepared, they will be more effective in carrying out emergency responsibilities. All major contractors and also suppliers should also reduce earthquake hazards. (Sporadic progress is being made in this area. The accomplishments of the Veterans Administration in strengthening hospitals nationwide is exemplary.)

Not only would a federal facilities program reduce hazards for a significant portion of the workforce, but it would also protect the federal government from avoidable losses and demonstrate to the community at large the importance of reducing hazards and the feasibility of risk reducing measures. Moreover, consultants, contractors, and planners trained while carrying out federal work would be better able to help local governments and private corporations.

This demonstration of leadership at the federal level would materially assist the earthquake hazard reduction effort in all seismically active regions and help establish this "critical mass" of programs that would be self-sustaining. This effort would be a tangible way for the federal government to help achieve California's goal to reduce statewide earthquake hazards

significantly by the end of the century.

In mid-February 1987, FEMA forwarded a proposed Executive Order to the Office of Management and Budget that would require use of seismic codes in new construction and renovations of existing facilities. This Executive Order will be a good start in reducing earthquake hazards, but Congressional oversight is needed to assure a meaningful policy is enacted expeditiously.

Financing Hazard Reduction

Reducing hazards in buildings, public or private, costs money, and can affect the supply of housing, cause dislocation, and raise rents. Few local governments have the financial resources to strengthen weak buildings and establish an adequate response capability. California is moving ahead with a $800 million bond measure to strengthen state-owned buildings, and is also considering offering state income tax credits to owners who strengthen potentially hazardous private buildings. Incentives are also needed at the federal level. Although the subject of incentives is too broad for the reauthorization hearing, unless the federal government helps provide meaningful incentives to those who invest in the often unprofitable endeavor of strengthening hazardous buildings, significant improvements in damage and death figures will not occur.

Recent experience in California with programs to strengthen hazardous buildings has revealed that, ultimately, risk reduction involves such basic issues as housing, redevelopment, and economic development at the local, state, and federal levels. In 1985, FEMA published a report titled *An Action Plan For Reducing Earthquake Hazards Of Existing Buildings*.[12] The plan assigns tasks and funds to responsible agencies. Unfortunately, it appears that this plan has not been supported by NEHRP agencies. This is another indication of the need for strong leadership. Congress should inquire about its status, and issue a directive that it is to be carried out.

Congress should also recognize the economic realities of hazard reduction and direct agencies with grant and funding programs, and those who can provide other incentives, to see that their programs and resources are used to strengthen dangerous buildings.

Program Priorities

The federal program must concentrate its limited resources in ways to reduce hazards in developed areas in accordance with the goals of the act. This can best be accomplished by focusing effort on reducing hazards in existing structures, preparing plans and developing capability for an emergency response effort, and assuring that existing knowledge is put to use.

Hazard reduction and emergency response planning involves complex interactions between numerous individuals, ranging from research scientists and political decision makers at all levels of

government to business leaders and private property owners. It involves research in a number of disciplines, legislation, education, professional practices, and government funding policies. These activities, organizations, and individuals must all be integrated to form a coordinated program. A coordinated program should have common priorities, and a balance among efforts.

A coordinated research and implementation strategy to deal with existing hazardous structures is needed. When research is directed towards real needs, and an implementation structure is in place, the results will be used. This is the reason why the Commission gave its support to a proposal to establish a research center focusing on hazardous structures. The Commission would have provided the assurance that the research results would have been translated into action and policy. Although the initial attempts to establish such a center were unsuccessful, there is still an urgent need for earthquake engineering research directed towards this high priority problem. Congress should find a way to assure that research directed towards the most critical seismic safety needs is funded in such a manner as to maximize its application.

The need for coordinated support for emergency management planning must be stressed. Preparing for earthquake emergency response in California results in a comprehensive emergency capability that can respond to most other natural and technological emergencies. A direct planning mechanism involving the federal government and local governments exists, and the new information is available, but FEMA's Emergency Management Assistance Program is directed to other issues and does not support the needed information transfer. Preparing the nation to respond to earthquake emergencies will strengthen the nation's overall emergency response capability.

New awareness of the nationwide threat of earthquakes has created a glaring need for increased technology transfer to decision makers, engineers, emergency response officials and others with front-line responsibility for earthquake safety. The demand is now nationwide further straining available resources. The gap between research accomplished and application of the results to reduce hazards is a major weakness of the program, and its getting worse. All of the agencies involved in the program have responsibilities for information transfer, but generally speaking these efforts are inadequate. For example, NSF and USGS support only small efforts to transfer their findings, and FEMA allocates less than $2 million of NEHRP funds to state and local earthquake preparedness activities. This level of effort is not enough, given the number and complex relationships of the organizations involved.

In California, little will be accomplished without the support of the officials of the nearly 500 local government bodies - mayors, city councils, Board of Supervisors, and their mangement staffs. The application of research results is often a political process, the persons involved are best reached through directed efforts and personal contact such as is provided by preparedness projects. Thus, increased funding for state and local preparedness planning, earthquake education, and information transfer is needed. Transfer of research results and new technology, and the application of this information, must be on the same priority level as advancing our

understanding and knowledge.

Furthermore, federal programs that provide funding for local government infrastucture, housing, and emergency management planning, and those that regulate certain activities, must support hazard reduction measures. For example, recent cuts in HUD's Community Development Block Grant Program severly retard efforts to strengthen existing dangerous buildings, especially those located in the central districts of our older cities. Similarly, recent changes to the federal tax code provisions for investment tax credits reduce the availability of development funds for needed projects. An agressive effort is needed to identify and enact federal incentives such as grants, tax credits, loans, loan guarantees, and other assistance programs to encourage local governments and owners to carry out hazard reduction projects.

The Parkfield experiment remains a high priority project in California; the state believes the experiment is of such value that it contributed $1 million during 1986 to improve the monitoring instrumentation, and is preparing a response plan tailored to deal with the prediction. The results of this plan will be used to assist other agencies deal with the political and legal realities arising from future predictions in urbanized regions. But the experiment also serves as an example of the lack of coordination in the federal program. Even though the USGS and the state have decided to emphasize this program, FEMA has not provided any support for the effort to plan the response to a prediction.

Matching FEMA Funds

FEMA has informed the states that beginning FY 88 NEHRP funds must be matched fifty-fifty by nonfederal funds. The state share must be "hard," with cash. The State of California has been matching federal funds on a fifty-fifty basis since 1980 for the Southern California Earthquake Preparedness Project, and since 1984 for the Bay Area Regional Earthquake Preparedness Project. Beginning July 1, 1987, California's share will increase, making the match 60-40. Requiring matching funds for certain programs is a reasonable requirement, but Congress must recognize the critical importance of unmatched federal funds for certain "start-up" programs. For example, such efforts as determining the vunerability of areas to earthquake hazards and increasing public awareness are often more practicable if nonfederal matching funds are not initially required. The Commission used unmatched FEMA funds to conduct the Bay Area Earthquake Study which lead to the present jointly funded BAREPP.

It is ironic that FEMA, because of pressure from the Office of Management and Budget, must require matching funds for the assistance programs that apply the research results of the other elements of NEHRP so successfully. Although matching funds are not an issue to the State of California, it is of critical importance to fledgling programs in other states. If the emphasis is to be on

implementing hazard reduction efforts, programs must encourage state and local participation. A hard requirement for matching funds will inhibit the success of the national program.

Earthquake Insurance

We urge the committee to consider earthquake insurance. Damage forecasts for a major earthquake in urban California could cause up to $70 billion in physical damage to buildings and their contents. Recent studies forcast fire damage up to an additional $17 billion[5]. According to the California Department of Insurance Probable Maximum Loss Study for earthquake insurance coverage in 1984, about $5 billion of insured property is covered for structures losses due to earthquakes. Insurance would cover $7 to $9 billion for fire damage. The remaining billions must come from savings, borrowing, the state and federal government.[13]

Present earthquake insurance satifies no one. Coverage limits are low, deductible limits and rates are high. Less than 15 percent of California households consider earthquake insurance a good investment. On the other hand, insurance companies feel over exposed, and have chosen to not offer insurance in high risk areas. Earthquake insurance neither serves as a significant source of private money to aid in recovery, nor does it encourage risk reduction.

Congress should consider the options in the Congressional Research Service reports, Earthquake Insurance: Problems and Options,[14] and make the necessary changes to encourage economically viable earthquake insurance programs that will provide private funds for rebuilding and encourage property owners to reduce existing hazards.

RECOMMENDATIONS

Federal Leadership Recommendations

- Adopt the goal to reduce nationwide earthquake hazards significantly by the end of the century.
- Form an independent, policy-level body to give overall guidance and oversight to the program.
- Require participating agencies to be accountable to the leadership organization.
- Combine appropriations for the program into a single line item in the President's budget to allow for integrated budgeting.
- Provide a mechanism to review the programs carried out by participating agencies to assure they are devoted to priority hazard reduction efforts.

Funding Recommendations

- Restore funding for the next fiscal year to the 1977 level before inflation.
- Provide adequate funding for new leadership activities.
- Increase funding for local and state government assistance.
- Determine future funding from the revised five-year plan and a careful review of the Newmark-Stever and Steinbrugge reports.

Program Priority Recommendations

The risk to life, property, and national security primarily involves hazards in areas already developed. NEHRP should reflect this fact by giving priority to programs that:

- Study active faults to determine paleohistoric earthquake return intervals and typical earthquake characteristics.
- Increase seismological and engineering research to determine ground motion criteria for the design of new buildings, and analysis existing buildings.
- Increase research on ways to identify existing buildings that are likely to be life-safety hazards during earthquake shaking.
- Develop engineering methods to reduce hazards from structural and nonstructural elements.
- Identify and map ground-failure hazards.

- Step up efforts to to apply knowledge that is available on earthquake hazards and reduction techniques.
- Improve the earthquake awareness of local and state governments, private companies, and the public.
- Aid in determining the vunerability of cities and regions to earthquake damage.
- Promote local government and private sector efforts to carry out hazard mitigation and emergency planning.
- Provide financial incentives to mitigate hazardous conditions.

Application of Research Recommendations

- Provide assurance that research is directed towards the most critical seismic safety needs.
- Give equal priority to the transfer of research results and new technology, and the application of new information, as is given to advancing our understanding and knowledge.
- Provide federal funds for planning emergency response to earthquake disasters.
- Initiate an effort to identify and enact federal incentives to encourage local governments and owners to carry out hazard reduction projects.

Facilities, Operations, and Contracting Recommendations

- The Office of Management and Budget should approve the Executive Order requiring agencies to apply seismic standards to new construction and to strengthen federally owned facilities whose collapse would endanger life, inhibit the federal government's ability to respond effectively during an emergency, or inhibit the federal government's ability to carry out necessary programs in the aftermath of an earthquake.
- Require emergency response plans, and employee training at all federal facilities.
- Require all major contractors and suppliers whose ability to operate and provide services and material is considered critical to adopt hazard reduction and employee training programs.

Matching FEMA Funds Recommendation

- Allow the use of unmatched federal funds for determining the vunerability of areas to earthquake hazards and increasing public awareness.

Earthquake FEMA Funds Recommendation

- Congress should consider the options in the Congressional Research Service reports, Earthquake Insurance: Problems and Options, and make the necessary changes to encourage economically viable earthquake insurance programs that will provide private funds for rebuilding and encourage property owners to reduce existing hazards.

REFERENCES

1 Seismic Safety Commission Act. California Government Code Section 8890, et seq.

2 Lindh, Allan G. (1983). Preliminary Assessment of Long-term Probabilities for Large Earthquakes Along Selected Fault Segments of the San Andreas Fault System in California, U.S. Geol. Surv. Open-File Report 83-63.

3 Steinbrugge, Karl V., Algermissen, S.T., Lagorio, Henry J., Cluff, Lloyd S., and Henry J. Degenkolb (1981) Metropolitan San Francisco and Los Angeles Earthquake Loss Studies: 1980 Assessment. USGS Open-File Report 81-113.

4 Commission on State Finance (1986). Impact of Federal Expenditures on California.

5 Scawthorn, Charles (1987). Fire Following Earthquake.

6 California Bankers Association (1983). Guidelines for an Emergency Response Plan.

7 Ziony, Joseph I. Ed.(1985). Evaluating Earthquake Hazards in the Los Angeles Region-An Earth Science Prespective, USGS Professional Paper 1360.

8 Building Seismic Safety Council (1985). NEHRP Recommended Provisions for the Development of Seismic Regulations for New Buildings.

9 Seismic Safety Commission (1986). California at Risk: Reducing Earthquake Hazards 1987 - 1992.

10 Earthquake Prediction and Hazard Mitigation Options for the National Science Foundation and United States Geological Survey, September 15, 1986.

11 Steinbrugge, Karl, Chairman, (1983). NEHRP Five-Year Plan Review Panel Report.

12 Applied Technology Council, Building Seismic Safety Council, and Earthquake Engineering Research Institute (1985). An Action Plan for Reducing Earthquake Hazards of Existing Buildings.

13 Department of Insurance (1986). California Earthquake Zoning and Probable Maximum Loss Evaluation Program.

14 Congressional Research Service (1987). Earthquake Insurance: Problems and Options.

Appendix A

THE CALIFORNIA PROGRAM

California is the state that is most at risk from earthquake hazards, and has responded with a broad program. The state spends about $25 million per year (see Figure 1) on earthquake safety programs. The following summary of key programs will illustrate the scope and level of our existing effort.

Safety of Dams Program

The Safety of Dams Program was initiated after the Saint Francis Dam failure in 1927, although the failure was not caused by an earthquake. The program, carried out by the Department of Water Resources, Division of Safety of Dams, has provided an excellent basis for a dam earthquake safety program. After the 1971 San Fernando earthquake caused the near collapse of Lower Van Norman Dam, the state reviewed the earthquake safety of all existing dams, increased its standards, and stepped up efforts to inspect and review dams periodically. Several dams have been substantially strengthened, and some totally rebuilt.

Uniform Building Code

Prompted by the 1925 Santa Barbara earthquake, a committee of structural engineers, architects, and contractors worked for several years on earthquake design standards, and the International Conference of Building Officials incorporated lateral force code requirements in the Uniform Building Code, (UBC). Use of the UBC, however, was not required by the state at that time.

The Riley Act

After the 1933 Long Beach earthquake, the state enacted the Riley Act that mandated the use of minimum wind and earthquake forces in building design. Today, regulations adopted by the state in Title 24 of the California Administrative Code incorporate the UBC as a minimum standard. The Department of Housing and Community Development is the state agency responsible for enforcing the Riley Act. The principal intent of the building code is to protect life in a major earthquake, rather than control damage or guarantee continued use of the structure after an

earthquake. In spite of the law, however, many local governments did not enforce seismic provisions until the 1950s.

The Field Act

Also after the 1933 earthquake, the state enacted the landmark Field Act that required public school buildings to meet special seismic safety requirements. Under the Field Act, all public school construction plans are prepared by a California architect or structural engineer. The plans are reviewed and constructionobserved by structural engineers and field representatives who work for the State Department of General Services, Office of State Architect. School boards are required to hire approved inspectors for detailed construction inspection for conformance with approved plans. This was the first instance of state preemption of municipal authority to regulate construction. Although public schools built subsequently have performed well in California earthquakes, there is serious concern about private schools, which are exempt from the Field Act standards and procedures. Concern has also been voiced about some of the public schools built decades ago in the early days of the Field Act, before its seismic standards were tightened on the basis of recent earthquake experience.

While existing private schools are not addressed in state law, a law enacted in 1986 requires special review of plans and construction of new private school structures similar to that required for essential services buildings (see below).

Special Studies Zone Act

After the 1971 San Fernando earthquake, the state enacted the Special Studies Zone Act (the Alquist-Priolo Act). It requires mapping of all active faults (faults with identifiable movement or surface rupture in the last 11,000 years), and calls for geologic studies if new development is proposed in identified active fault zones. The mapping is carried out by the Department of Conservation, Division of Mines and Geology. Local governments enforce the act by requiring geotechnical reports and approving, modifying, or denying building permits. Placement of structures in known active fault zones is thus carefully regulated, but California still has significant risks from fault rupture because:

1. Many buildings were built in active fault zones before the act was passed.

2. Faulting may occur in unmapped areas.

3. The law exempts dwellings with fewer than five units.

Bridge Strengthening Program

The collapse of several highway structures in the San Fernando earthquake of 1971 prompted the Department of Transportation to identify 1,300 bridges and overpasses statewide that needed seismic strengthening. Cable restrainers have been installed on nearly 1,200 of these structures to prevent them from collapsing. Since the program began, only one bridge has been damaged, and its restrainers prevented the bridge deck from suffering complete collapse.

Strong Motion Instrumentation Program

Recognizing that laboratory and shaking-table tests and mathematical studies, while extremely valuable, cannot fully or adequately predict the actual seismic performance of real structures, the State of California embarked on a program to install strong motion instruments in representative structures throughout the state. The Department of Conservation, Division of Mines and Geology, is responsible for installing and maintaining the instruments, reading the data, and analyzing and disseminating the results. The value of this program was demonstrated when records of the 1979 Imperial Valley earthquake led to changes in the UBC.

Hospital Seismic Safety Act

The collapse of the Veterans Hospital in the 1971 San Fernando earthquake took 44 lives, and Los Angeles County's newly opened Olive View Hospital was damaged beyond repair. This experience prompted the state to adopt the Hospital Seismic Safety Act, once again preempting what had been a municipal responsibility. This law requires all new hospitals to meet state-imposed standards to ensure that they not only survive but remain operational after an earthquake. Plans for new hospitals are subjected to rigorous independent review, and construction is inspected by the Office of Statewide Health Planning and Development and the Office of State Architect. This law is not retroactive, however, and at present only seven percent of the hospitals in California meet the standard. A major earthquake that struck a large urban area today would probably make between one-third and one-half of the hospital beds unusable.

Land Use Planning Law Amendment

The basic Land Use Planning Law was amended in 1972 to require that all municipalities include a seismic safety element in their land use plans, and to consider the information in making land use decisions. Although seismic safety elements are mandated, no standards or enforcement procedures have been provided to assure their quality.

School Emergency Planning

A 1984 state law requires all schools to prepare emergency plans and to practice using them. The Seismic Safety Commission has provided every school in the state with a copy of a how-to guidebook on developing school earthquake safety programs prepared by the Federal Emergency Management Agency.

Essential Services Buildings Act

A 1985 state law requires that all new police and fire stations, emergency operations centers, and communications facilities be built so as to remain operational during and after an earthquake. Design drawings are subject to independent review and special inspection by the local government. In addition, the designer of record is required to visit the job site during construction.

Unreinforced Masonry Building Program

A law passed after the 1985 Mexico City earthquake mandated that municipalities identify all unreinforced masonry buildings built before codes were adopted, and adopt programs to address the hazard. This must be done by January 1, 1990. It has been estimated that approximately 40,000 to 50,000 of these structures are still in use, and studies indicate that nearly nine out of ten of them would probably suffer life-threatening failures when shaken by a damaging earthquake. Only seven California municipalities — Los Angeles, Long Beach, Santa Rosa, Santa Ana, Santa Monica, Palo Alto, and Sebastopol — had acted prior to passage of this mandate to adopt hazard-reduction programs

Earthquake Preparedness Campaign

Acting primarily through the Office of Emergency Services, the state conducts an Earthquake Preparedness Campaign, highlighted by an annual Earthquake Week. Public awareness of earthquakes and understanding of their effects are

critical to reducing hazards and improving response. These efforts are intended to strengthen public support for earthquake safety measures, and to drive home to people the realization that they, as individuals, should and can take steps to improve their own and their families' safety, so that they will be more strongly motivated to act.

Emergency Response Plans

Being on the front line, cities and counties are typically the first jurisdictions to respond after an earthquake. They are encouraged to have local emergency response plans that are certified by the state Office of Emergency Services. When an emergency requires resources that are beyond its capability, an individual local government can request help from neighboring jurisdictions through mutual aid agreements. When an emergency exceeds *regional* response capabilities, the state mobilizes support. The Office of Emergency Services has prepared a new earthquake emergency response plan for southern California, an area with 180 municipalities and 12,000,000 people. The new plan was adopted in concept by the Governor's Emergency Council on February 26, 1987.

State Emergency Operations Center

A new state emergency response center for southern California is being designed for use as an operations center in responding to future earthquakes.

Dam Inundation Mapping Program

After the near collapse of Lower Van Norman Dam in the 1971 San Fernando earthquake, owners of dams throughout the state were required to map areas that would be flooded in case of dam failures. Local municipalities can use these maps in making plans to evacuate populations exposed to possible inundation.

Parkfield California Earthquake Plan

Scientists are not yet generally able to predict earthquakes with any degree of precision, but there is a unique situation in Parkfield on the San Andreas fault in central California. The unusual regularity of past earthquakes there leads experts to expect a moderate earthquake in January 1986. Scientists have installed sensitive scientific instruments in an attempt to detect precursors to the expected earthquake, and if warranted by the evidence a short-term prediction will be issued. In view of this

possibility, a short-term prediction response plan is being prepared, the first ever in California.

The California Earthquake Education Project

The California Earthquake Education Project (CALEEP) was established in 1981 to develop educational materials in earthquake science and hazard reduction and response for grades 4-8. Now that tested materials are available, efforts are being directed at teachers to help them develop effective ways to use the materials. Ways are also being sought to incorporate the materials into the curricula of all primary schools in the state.

Earthquake Preparedness Projects

The Southern California Earthquake Preparedness Project (SCEPP) and the Bay Area Regional Earthquake Preparedness Project (BAREPP) provide technical assistance to local governments and business firms on hazard reduction and emergency preparations, and have developed earthquake preparedness planning materials to assist cities, counties, businesses, and community organizations. Both projects are guided by policy advisory boards consisting of community leaders and experts. The projects host conferences and workshops, and work with the media to promote awareness, mitigate hazards, and plan for emergency response.

Appendix B

FUTURE PRIORITIES AND PROGRAMS

California's five-year program, *California At Risk: Reducing Earthquake Hazards 1987-1992,* provides a number of new initiatives needed to reduce statewide earthquake hazards significantly by the end of this century. The following summary of new initiatives are to be carried out in California during the 1987 calender year.

Existing Development

Dealing with hazardous existing developments is expensive, but this is what will save the most lives in future earthquakes. Accordingly, California must begin working on these initiatives now. The following new initiatives are proposed for Existing Development:

- *Buildings constructed of unreinforced masonry* - Under legislation signed into law in August 1986, cities and counties in Seismic Zone 4, the most active seismic area, must inventory unreinforced masonry buildings and adopt hazardous-building mitigation programs to strengthen, raze, or otherwise reduce hazards associated with occupancy of such buildings.

- *Pre-Hospital Act structures* - Complete a survey of hospitals constructed prior to 1973, and evaluate the results to determine the probable loss of operational capacity following an earthquake. Prepare recommendations for measures to strengthen such buildings, and develop a schedule to reduce these hazards.

- *Mobile Homes* - Implement recently enacted legislation to reduce the vulnerability of mobile and manufactured homes through the use of earthquake-resistant foundation systems.

- *Early public school buildings* - Survey construction documents of public schools designed and built in the early years of the Field Act to determine whether any significant life-safety hazards exist. Identify those facilities in need of strengthening and prepare a program to reduce the identified hazards.

- *State-owned buildings* - Seek legislation and voter approval for $800 million in general obligation bonds to strengthen or remove hazardous state-owned buildings (including those owned by the University of California and the California State University system).

- *Incentives for hazard reduction* - Enact legislation offering incentives, such as state income tax credits, to property owners to encourage them to strengthen hazardous facilities.

- *Building codes* - Change existing building codes to require seismic strengthening of structures when repaired or remodeled for other purposes.

Emergency Planning And Response

Emergency response also has a high priority. Moreover, improving the state's emergency response capability is much less costly than renovating existing structures. The following new initiatives are proposed for Emergency Planning and Response:

- *Emergency Planning* - The state Office of Emergency Services (OES) should complete and adopt the Southern California Earthquake Response Plan, and develop a concept of operations for statewide emergency response. A similar plan should be adopted for the San Francisco Bay Area.

- *Emergency Operation Centers* - The state should establish and maintain a permanent Emergency Operations Center in southern California for managing regional disasters. This center should be capable of operating after a large-magnitude earthquake. The state also should evaluate the need for a similar operations center in northern California. All city and county governments should have local emergency operations centers. It is crucial that local centers be capable of surviving and functioning effectively after a large-magnitude earthquake.

- *Short-Term Earthquake Prediction Response Plan* - The state should develop a Short-Term Earthquake Prediction Response Plan to provide state agencies with specific response actions, and to provide local jurisdictions with standard and consistent guidance on recommended local response actions in the event of a short-term earthquake prediction. Experience gained from the Parkfield Project should be evaluated for lessons in dealing with short-term predictions.

- *Emergency Management Systems* - OES should develop and adopt a standard computer-based emergency management system to facilitate the statewide coordination of emergency personnel and equipment, and assist with state direction and control functions during regional disasters.

- *Communications* - The state should develop and install communications system capable of surviving and operating effectively immediately after an earthquake and linking state agencies with each other, with the state coordination centers, and with designated local government facilities.

- *Urban Heavy Rescue* - OES should develop a search-and-heavy-rescue training program with ready access to specialized equipment for removing people from collapsed buildings. Plans should also be developed for integrating rescue and medical operations.

Future Development

California cannot afford to construct new buildings in hazardous areas where hazard mitigation is not practicable, and where the effect of earthquakes on structures is likely to endanger lives. New initiatives proposed for new development include the following:

- *New private schools* - Implement legislation signed into law in August 1986, requiring more careful checking of plans for private schools and more careful observation of their construction.

- *Local general plan review* - Enact legislation requiring local governments to review the seismic portions of local general plans periodically, so they can be updated with new information on seismic hazards, and appropriate measures taken.

- *Subdivision hazard review* - Require the evaluation of proposed new subdivisions for onsite hazards, as well as for offsite hazards — e.g., upstream dams — unless the requirement is specifically waived by the responsible local jurisdiction. Local governments should assure careful evaluation of any proposed development prior to approving any plans to locate a subdivision where there is a significant potential for unusual seismic hazards.

Recovery

In California little has been done to plan for post-earthquake recovery. Our worst-case loss estimates forecast about $50 billion in physical damage from a major earthquake in a metropolitan area. We are learning from Mexico City's experience that economic and social disruption will be of long duration, human and material resources will be in short supply, and government at all levels will face politically difficult choices. The program calls for the following new initiatives for post-earthquake recovery:

- *Local reconstruction authorities* - Legislation enacted authorizing local governments to create local reconstruction authorities and preparation of a model recovery plan should be carried out. The model plan should include the authorities and procedures for the orderly transition from emergency disaster response operations to short-range and long-range recovery efforts. Local jurisdictions should be encouraged to develop recovery plans and ordinances.

- *Review earthquake insurance* - Legislation should require the state Department of Insurance to conduct a

comprehensive review of the insurance industry's earthquake-insurance offerings and of the public's acceptance, along with an examination of other issues relating to the scope of coverage and the probable contribution of insurance benefits to earthquake recovery.

- *Effects on state government* - The state should assess the consequences of a major earthquake on California state government, including revenue losses, increased demand for state services, unemployment costs, and losses of state property. Such an assessment will provide the basis for mitigation and recovery policymaking and planning.

- *Effects on the state's economy* - The state should assess the impact of a major earthquake on the state's economy, considering the vulnerability of the financial system and of particular industries, businesses, and utilities.

Education And Public Information

Educational efforts are needed to improve public understanding of earthquakes and of the value of hazard-reduction measures, as well as of the need for emergency preparedness measures. The program proposes the following new education and public information initiatives:

- *Earthquake preparedness campaign* - The state should provide permanent funding to the Office of Emergency Services to continue the earthquake preparedness campaign, and work with the media and the private sector to develop and broadcast earthquake preparedness public service announcements and distribute educational materials.

- *Earthquake science and preparedness curricula* - The Seismic Safety Commission should determine whether the California Earthquake Education Project (CALEEP) should be extended, and what role it should play in earthquake curriculum development and dissemination. The Commission should encourage the state Department of Education, CALEEP, and others to incorporate earthquake education into elementary, junior high (middle), and high school classes statewide.

- *School preparedness* - The Seismic Safety Commission should work to strengthen legislation requiring public and private school earthquake safety plans, including a requirement that every two years public schools file with their districts current earthquake safety plans that include the names of the school safety officers. A Safety Officer should be established in the state Department of Education.

- *Regional projects* - The Southern California and Bay Area Regional Earthquake Preparedness Projects will continue their mission of reducing earthquake hazards and preparing for emergency response and recovery in their

respective areas until June 30, 1990. In consultation with the Office of Emergency Services and other affected agencies, the Seismic Safety Commission should determine whether similar projects should be established for other seismically active areas such as San Diego, Santa Barbara, or the Central Valley.

Research

We need to learn more about the causes and effects of earthquakes; the responses of structures, sites and materials; and the economic, legal, social, psychological, and other consequences. Research on such matters is a long-term investment in the future, and the program proposes the following new research initiatives:

- *The "California Center for Earthquake Engineering,"* authorized by legislation enacted in July 1986, should be established with matching funds from the National Science Foundation, or other sources.

- *Earthquake Early Warning System* - Recently enacted legislation requires the Department of Conservation to evaluate the feasibility of an early warning system for earthquakes. This study should be completed.

- *Strong Motion Program* - Legislative or administrative action should increase funding for the Strong Instrumentation Program, whose efforts need to be increased so that the highest priority typical structures will be instrumented by the end of the century.

- *"Five-Year Research Plan"* - The Seismic Safety Commission should establish research priorities based upon California's seismic safety needs and, in cooperation with appropriate state agencies, develop a comprehensive five-year research plan and strategy for carrying it out.

Appendix C

LOCAL GOVERNMENT EARTHQUAKE SAFETY PROGRAMS

- The City of Los Angeles has enacted an ordinance requiring owners of unreinforced masonry buildings to strengthen their buildings. It will cost property owners nearly $1 billion to comply.
- The City of Los Angeles also has well developed hazard reduction, emergency planning, prediction planning, and employee training programs.
- Los Angeles County is upgrading its emergency communication system so that it will operate after an earthquake, and is strengthening six firehouses that were found structurally deficient.
- Orange County recently committed $3.1 million to carry out the second phase of a well planned hazard reduction program.
- San Bernandino County has embarked on an ambitious plan to construct the new Eagle Emergency Operations and Training Center, which will be capable of functioning after an earthquake.
- All the cities in Santa Barbara recently signed a joint powers agreement to establish an emergency services organization.
- In 1986, the City of San Francisco voted overwhelmingly (89% in favor) of a $46 million bond measure to strengthen its post earthquake firefighting capability and to finance construction of a new emergency operations center.
- The City of San Francisco recently completed an inventory of all unreinforced masonry buildings, and has notified the owners. Work continues on an ordinance to require strengthening.
- The City of Oakland recently recreated an Office of Emergency Services in the City Manager's office after serveral years of not having such an activity.
- The City of Santa Rosa has identified and strengthened all of its uninreforced masonry buildings.
- The City of San Jose is preparing a long term master plan to reduce hazards and prepare for response to an earthquake.
- The San Diego County Board of Supervisors has adopted a comprehensive policy and established an Earthquake Preparedness Committee.
- The cities of South Pasadena and Monterey Park have recently adopted ordinances requiring owners to strengthen unreinforced masonry buildings.
- The City of Palo Alto has identified all buildings considered potentially hazardous during an earthquake, and adopted an

ordinance requiring notification of owners and posting of unreinforced masonry buildings.

- All jurisdictions in Seismic Zone 4, over four hundred cities and counties, are required to inventory unreinforced masonry buildings and adopt mitigation programs by 1990.

Appendix D

PRIVATE SECTOR EARTHQUAKE SAFETY PROJECTS

- California Banker's Clearinghouse, consisting of the Federal Reserve Bank and the state's largest banks (Bank of America, Wells Fargo, First Interstate, Security Pacific), has established a system to reestablish operations after an earthquake, created a radio network to link the banks within a region in case an earthquake destroys normal communication capabilities, entered into standby contracts to transport employees and records to remote processing centers, strengthened computer systems to improve their ability to resist earthquake forces, and provided research money to supplement NSF funding.

- Pacific Bell, Continental Telephone, GTE, AT&T, MCI, and other communications companies voluntarily joined to prepare an emergency response plan including liaison with state and local government emergency officials, provision of emergency telephone service, and a priority system for restoring normal service. These companies have invested several million dollars installing bracing and other hazard mitigation measures.

- Pacific Gas and Electric has prepared disaster plans for each installation, stored emergency response equipment and food, trained employees to undertake leadership roles in disaster situations, and conducted a major training program for employee safety in the workplace and at home. It is believed that employees will be far more effective in an emergency if they are confident that their families are safe.

- The San Francisco Symphony spent an extra $8 million to provide for increased earthquake safety in the construction of their new symphony hall, adopted emergency procedures, and routinely trains ushers to respond properly to a damaging earthquake.

- Chevron is preparing a corporation wide disaster plan focusing on earthquakes.

- IBM, recognizing its vulnerability to earthquakes in the San Jose region, spent about $25 million improving the earthquake safety of two of its buildings during the last six years.

- Hewlett-Packard is carrying out earthquake hazard reduction measures at its Palo Alto facility to strengthen its mainframe computer facilities.

- In Southern California, the Business-Industry Committee for Earthquake Preparedness (BICEP) has provided a forum for businesses to promote hazard mitigation and preparedness.

- The Industrial Council of Santa Clara-San Mateo Counties, a consortium of high technology businesses formed to develop its own earthquake response capability, provides training for members and operates its own emergency response vehicle.

Senator GORE. Thank you very much.

Let me ask a few more questions. We are going to have to close the hearing fairly soon, so I will only ask a few.

First of all, Dr. Johnston, in the past, you and I have talked on many occasions and I have visited your center and enjoyed working with you. In the past you have calculated that there is a high probability of a relatively destructive earthquake in the New Madrid area, before the end of this century.

That, of course, concerns me and other Tennesseeans as well as the residents of our neighboring states a great deal, since a recent report, which I cited earlier, described the enormous damage which would accompany a relatively large quake.

In the two years since you last testified on this subject, have you changed your estimates? Has anything led you to look at it differently?

Or is there still a high probability of a destructive earthquake, in your view, between now and the turn of the century?

Dr. JOHNSTON. Mr. Chairman, those estimates are just that, and they have some fairly wide uncertainties because of lack of data.

They are also very magnitude dependent. The probabilities are considerable for the magnitude 6 range, which is the lower range of dangerous earthquakes.

They are very low for a repeat of the great earthquakes of 1811 and 1812. But the critical data that I feel we are lacking, since the repeat time of large earthquakes is so much longer than out West, is geologic evidence of past earthquakes, before there was any historical record.

We are trying to—our organization and several others are trying to attack that problem. Since my last testimony, however, there are no new data along those lines.

So the estimates remain as previously quoted.

Senator GORE. Well, that answer, again, points up the need for collecting good data and learning more about the nature of the problem.

And toward that end, you have recommended strongly that we maintain a comprehensive set of university-based seismic networks, even as we also construct the national network that is now planned.

Do you have any estimates of what the costs of maintaining the university-based networks for the central and eastern states might be?

Dr. JOHNSTON. Senator, I think perhaps the first panel could have answered that better. The NRC budget per year for their 15 to 18 networks, and one or two of those small ones are in the West, I think is over $2 million.

I know that they're budgeting $5 million for the transfer to USGS.

Senator GORE. Right. We can invite you to add for the record additional comments in response to that question.

Dr. Beavers, in your statement you talked about efforts to develop better building codes for the region east of the Rockies.

What kind of approach makes the most sense in developing building codes for the East? Should we try to uniformly apply the

seismic standards of the Uniform Building Code throughout the entire east?

Or do we have enough information on seismic hazards to say that certain areas face high risks, and therefore, should have stricter codes, while other areas can safely use a less stringent approach?

Dr. BEAVERS. Well, there are a couple of ways, Mr. Chairman, that this can be approached. Right now, the basic technology exists to where codes could be developed and adopted that in future earthquakes would minimize damage.

And as I have said in my written testimony, something is better than nothing.

Obviously, to fine tune the code systems, there may be some areas, such as the New Madrid area, where the code would be more stringent.

Primarily, though, we are just talking about levels of expected earthquake. We are talking about a level of risk, the probability of the life of a structure that an event will occur.

And you just use different forcing values in your calculations, and in a sense, in my opinion, you can use the same standards, you just don't apply them in as much detail or at as high levels as you go from one region to another.

Senator GORE. I see. Now, you also pointed out in your statement the heavy investment by the Japanese in earthquake research including a large number of advanced shake tables.

How much of that Japanese investment in earthquake R&D is being made by their government, and how much is being made by private companies?

Dr. BEAVERS. A lot is being made by their government. Also, relative to our industries, a lot is being made by the private sector in Japan.

In fact, the MTS Systems Corporation has just sold a new shake table to one of the engineering and construction firms, so they are really heavy into the business.

They are going to sell the earthquake business around the world, and we are losing out.

Senator GORE. Well, actually, in many, many areas of the world, it makes excellent economic sense to require new construction to conform to much tougher earthquake resistant standards, correct?

Dr. BEAVERS. That is correct. There are 40 countries around the world that experience significant earthquakes. And in today's global market, this country has to be right at the cutting edge of the earthquake technology to be able to compete.

Senator GORE. So architectural and engineering firms and construction companies that can offer the state of the art earthquake resistance are going to have an enormous competitive advantage?

Dr. BEAVERS. That is correct.

Senator GORE. And here, as in some other areas, the Japanese are looking farther into the future, making clearer decisions, and making stronger commitments to an area that has enormous competitive implications, correct?

Dr. BEAVERS. This is correct.

Senator GORE. Would more collaborate research among major U.S. construction companies and A&E firms help to redress that imbalance?

Dr. BEAVERS. Yes.

Senator GORE. Mr. Tobin, in your prepared statement, you discuss what you believe is a lack of cooridination, a lack of clear leadership, and a lack of accountability in the Federal earthquake program.

How have these programs limited the effectiveness of the Federal effort? And does this kind of fragmentation mean that key needs in the states are simply not being addressed?

Mr. TOBIN. Well, Mr. Chairman, I believe it does mean that key needs are not being met.

Let me give you a few examples. At Parkfield, there is an extremely exciting experiment on earthquake prediction being carried out by the U.S. Geological Survey. This prediction raises a number of questions regarding public policy.

What do you tell local governments? What action do they take? Who is liable? What decisions will follow after that prediction is made down to a week or an hour?

None of the work that is being done to cope with those public policy issues is being funded either by the National Science Foundation as part of their programs, or by FEMA.

It is being carried out by California working with the local governments. We are doing it to cope with the situation that was brought to us, gladly so, by the national program. But it is not a coordinated effort.

Obviously, we have seen a large investment in New York for earthquake research. On the other hand, we don't see the parallel investment in with the local governments and other agencies in New York. It is necessary to apply that information.

In California we have what we consider a very rare opportunity, because state laws and local government interests are coming together at a point now where we need information to start carrying out strengthening projects for vast numbers of dangerous buildings. We believe we have 40,000 unreinforced masonry buildings in California that will need to be strengthened. But the techniques to do it, the code forces, the legal definition of "standard of care" for the engineering practice, have not been defined to a point where there is a consensus, and where we can go ahead and carry this program out in an efficient, economically and socially efficient manner.

These are some examples that we see at the cutting edge.

I would like to add another point, and that is that earthquake safety is not simply an engineering or a geologic problem. It becomes very much of a social problem.

In San Francisco, Los Angeles, and in older inner cities where these buildings exist, we are finding it doggone hard to get the money to strengthen buildings that are owned in the private sector. These buildings provide low cost housing, and there isn't money available to go ahead and carry out the reasonable strengthening projects that are absolutely necessary to protect a very large segment of our society.

So we do need a much more coordinated aggressive program where these kinds of issues are brought out across the board. It's

not just the four principal agencies in the national program. It is the activities of the entire United States government.

Senator GORE. Very good. Well, again, the subcommittee may have a number of questions for the record if you all would be willing to respond in writing for the record.

And I would like to close the hearing by thanking the members of this second panel, and the members of the first panel as well, as well as all who have assisted in today's hearing.

We will be moving expeditiously toward reauthorization, and we hope to incorporate many of the useful suggestions made by the witnesses today.

So thank you very much, and this hearing is now adjourned.

[Whereupon, at 11:55 a.m., the hearing was adjourned.]

[The following information was subsequently received for the record:]

STEVE COWPER
GOVERNOR

STATE OF ALASKA
OFFICE OF THE GOVERNOR
JUNEAU

April 21, 1987

The Honorable Donald W. Riegle, Jr.
Chairman
Science, Technology, and Space Subcommittee
SH-427 Hart Senate Office Bldg.
Washington, D.C. 20510

Dear Chairman Riegle::

I am writing to present the State's views on reauthorization of the Earthquake Hazards Reduction Act. This act and the funds provided by the U.S. Congress to execute its objectives have been of substantial benefit to the State of Alaska. Since 1978, the USGS has provided to the Alaska Department of Natural Resources both funding and expertise to establish an earthquake hazards reduction program. This "seed money" from the USGS has established expertise within the state Geological and Geophysical Survey (ADGGS).

The ADGGS has used these funds for several important earthquake hazard reduction studies. These studies have benefited the State in siting schools and other public buildings, planning and zoning urban areas, upgrading building codes, and substantially increasing public awareness of earthquakes and how to mitigate the hazards associated with this phenomena. The strong, continuous cooperation between Alaska and the federal agencies is an excellent example of meeting the original intent of the act.

From the inception of the act, funds have been focused on critical areas of the U.S., as defined by the probability for near-future major earthquakes, combined with population density. Areas such as San Francisco, Los Angeles, Salt Lake City, and Puget Sound have received priority attention. However, Alaska has been gradually receiving greater attention, and it is anticipated that within 3 to 5 years this state will be a top priority area for the earthquake hazards reduction program. Alaska merits this consideration given its importance to national security and the national economy. As you know, the Trans-Alaska pipeline and several important military installations are located in the State.

We in Alaska are "in a race" to get prepared for the next major earthquake. If an event similar to the March 27, 1964 earthquake were to strike southcentral Alaska in 1987, the devastation would be extensive. The Earthquake Hazards Reduction Act with its funding support of agencies such as FEMA, USGS, and ADGGS is the only coherent means we have to get ready for any eventuality.

Because of the excellent technological and financial support that the state has received through this act, I recommend that you vigorously support continuation of the Earthquake Hazards Reduction Act. Thank you for your consideration of this correspondence.

Sincerely,

John W. Katz for

Steve Cowper
Governor